Photographic reproduction of bronze medal voted to Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station by the Wisconsin State Legislature of 1899, and presented during the legislative session of 1901.

"Recognizing the great value to the people of this state and to the whole world of the inventions and discoveries of Professor STEPHEN MOULTON BABCOCK *of the University of Wisconsin, and his unselfish dedication of these inventions to the public service, the State of Wisconsin presents to Professor Babcock this Medal."* (See page 6.)

EIGHTEENTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN

For the year ending June 30, 1901.

MADISON
DEMOCRAT PRINTING COMPANY, STATE PRINTER
1901

☞ **The Bulletins and Annual Reports of this Station are sent free to all residents of the State upon request.**

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LIST OF OFFICERS.

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General Offices and Departments of Agricultural Chemistry, Animal Husbandry, Bacteriology, Farmers' Institutes and Library, in Agricultural Hall, near University Hall, on Upper Campus.

Dairy Building and Joint Horticulture-Physics Building, west end of Observatory Hill, adjacent to Horticultural Grounds and Experiment Farm.

Telephone to Station Office, Dairy Building and Farm Office.

*Absent on leave to Oct. 1, 1901.
†To Nov. 1, 1901.
‡To Oct. 1, 1901.
§Physicist after Nov. 1, 1901.
**Absent on leave after July 1, 1901.
††After July 1, 1901.

LETTER OF TRANSMITTAL.

MENOMONIE, WIS., DECEMBER 1st, 1901.

To his Excellency, ROBERT M. LA FOLLETTE,

Governor of Wisconsin:

I have the honor to transmit to you herewith, in accordance with law, the Eighteenth Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

JAMES H. STOUT,

President of the Board of Regents.

REPORT OF THE DIRECTOR.

In presenting the eighteenth annual report of the Wisconsin Agricultural Experiment Station to the farmers of Wisconsin, a number of important matters should be recorded.

The legislature of 1901 appropriated to the University $150,000 for a central home building for the College of Agriculture. Plans have been prepared by Superintending Architect Jennings, and it is hoped the structure will be completed during the winter of 1903. The site for the proposed building is on the south slope of Observatory Hill, about midway between the Washburn Astronomical Observatory and the Hiram–Smith Dairy Hall. No provision was made for furnishing and equipping the building, it being understood that the necessary appropriation will be allowed by the next legislature.

Additions to the Dairy Building.—The addition to the Dairy building, providing quarters for the foreign cheese department, was described in the seventeenth annual report. At the north end of the Dairy building there is now being completed an addition which includes a double refrigerator, a wash room, a pasteurizing room and a butter-working room. The floors of these rooms are of figured tiles and the walls of the last two rooms are lined with opalite tiles. Electric motors operate the machinery. The Dairy Department is being equipped with a 12 H. P. tripple compressor ammonia refrigerating machine driven by a 20 H. P. electric motor, furnished and installed by the Geo. Challoner's Sons Co., of Oshkosh, Wis. These additions to the building and equipment will materially increase the efficiency and usefulness of the Dairy Department.

Changes at the Farm.—At the farm the farm house, Superintendent's cottage and old dairy building have been moved to

new locations facing Box-elder Drive, now known as "Farm Place." These buildings are being renovated and put in first class condition. Their removal clears a large space of ground which is reserved for future educational buildings, such as poultry, veterinary, etc. It further makes possible the suitable joining of Linden and Green Ash Drives.

The Babcock Medal Presentation.—The legislature of 1899 provided that a medal be presented to Dr. S. M. Babcock, Assistant Director and Chief Chemist of the Experiment Station, in recognition of his scientific services to the people. An account of the presentation appears in this report, as does also a half tone reproduction of the medal. All the farmers of Wisconsin will join with the Director in the wish that Doctor Babcock be spared many years yet to serve the Station and the people.

Changes in Station Force.—With deep regret the Director reports the withdrawal from the Station force of Prof. F. H. King, who for many years past has so ably conducted the Department of Agricultural Physics. Mr. King's services to agriculture are not only known and recognized by the farmers of Wisconsin, but are appreciated by the agricultural people of the whole country. Fortunately for agriculture, Mr. King leaves us for a larger field of usefulness, being placed in charge of a division in the Department of Agriculture, Washington, D. C. The department he leaves will be in charge, temporarily at least, of Mr. A. R. Whitson, who has served as Assistant Professor in Agricultural Physics during the past two years.

During the past year Mr. F. W. Woll, Chemist of the Station, has been absent in Europe, pursuing studies in agricultural chemistry, his place here being filled by Mr. R. H. Shaw, formerly Assistant Chemist of the New Hampshire Experiment Station.

At its spring meeting the Board of Regents appointed Mr. T. F. McConnell, Jr., Instructor in Animal Husbandry. By this addition the department of Animal Husbandry has been materially strengthened.

Dr. A. G. Hopkins, Veterinarian, resigned early in the year to undertake agricultural journalism in Canada. No successor has been appointed.

Mr. E. G. Hastings, Assistant Bacteriologist, resigned to continue studies in his chosen line in Europe; his place is filled by Mr. John F. Nicholson, a graduate of this University.

Mr. Frank Dewhirst, Dairy Instructor, resigned during the summer to enter business life; his place has not yet been filled.

Publications.—During the year ending June 30th, 1901, the Experiment Station issued the following publications:

Bulletin No. 84	20,000 copies,	16 pages each,	320,000 total pages
Bulletin No. 85	3,000 copies,	48 pages each,	144,000 total pages
Bulletin No. 86	12,000 copies,	10 pages each,	120,000 total pages
Bulletin No. 87	13,000 copies,	31 pages each,	403,000 total pages
Special Bulletin	40,000 copies,	2 pages each,	80,000 total pages
Special Bulletin	40,000 copies,	2 pages each,	80,000 total pages
Special Bulletin	50,000 copies,	4 pages each,	200,000 total pages
Totals	178,000 copies,	113 pages,	1,347,000 total pages
Annual report	15,000 copies,	352 pages,	5,280,000 total pages
Total pages of reports and bulletins			6,627,000

The above shows that during the year there were published by the Station seven bulletins and an annual report, containing in all 465 pages of printed matter, all prepared by the workers of the Station. During the year 6,627,000 pages of printed matter in the form of reports and bulletins were distributed from the Station, nearly all going to the farmers of Wisconsin.

Available Publications.—Most of our earlier publications are now out of print. We have on hand and will supply to residents of this state only, upon request, until exhausted, any of the following:

Thirteenth Annual Report for the year 1896.
Fourteenth Annual Report for the year 1897.
Fifteenth Annual Report for the year 1898.
Sixteenth Annual Report for the year 1899.
Seventeenth Annual Report for the year 1900.
Bulletin No. 28. The Construction of Silos. July, 1891.
Bulletin No. 29. Creaming Experiments. October, 1891.
Bulletin No. 32. Feeding Grain to Lambs. July, 1892.
Bulletin No. 35. Insects and Diseases Injurious to Cranberries. April, 1893.
Bulletin No. 37. The Russian Thistle. October, 1893.
Bulletin No. 38. One Hundred American Rations for Dairy Cows. January, 1894.
Bulletin No. 41. Grain Feeding Lambs for Market. August, 1894.

Bulletin No. 42. Destructive Effects of Winds on Sandy Soils and Light Sandy Loams, With Methods of Protection. October, 1894.

Bulletin No. 43. The Agricultural, Horticultural and Live-Stock Features of a Portion of Wisconsin Tributary to Superior. January, 1895.

Bulletin No. 46. Power Tests of Centrifugal Cream Separators. October, 1895.

Bulletin No. 48. The Conn Culture (B41) in Butter Making. January, 1896.

Bulletin No. 52. A Comparison of the Babcock Test and the Gravimetric Method of Estimating Fat in Skim Milk. The Alkaline Tablet Test of Acidity in Milk or Cream. July, 1896.

Bulletin No. 53. Analyses of Licensed Commercial Fertilizers. July, 1896.

Bulletin No. 54. The Restoration of the Consistency of Pasteurized Cream. August, 1896.

Bulletin No. 55. Beet Sugar Production: Possibilities for a New Industry in Wisconsin. December, 1896.

Bulletin No. 60. The Cheese Industry: Its Development and Possibilities in Wisconsin. May, 1897.

Bulletin No. 61. The Constitution of Milk with Especial Reference to Cheese Production. September, 1897.

Bulletin No. 62. Tainted or Defective Milks: Their Causes and Methods of Prevention. September, 1897.

Bulletin No. 63. The Culture of Native Plums in the Northwest. October, 1897.

Bulletin No. 64. Sugar Beet Investigations in Wisconsin During 1897. January, 1898.

Bulletin No. 65. A Bacterial Rot of Cabbage and Allied Plants. February, 1898.

Bulletin No. 66. Analyses of Licensed Commercial Fertilizers. April, 1898.

Bulletin No. 67. Factory Tests for Milk. June, 1898.

Bulletin No. 68. One Year's Work Done by a 16-Foot Geared Windmill. June, 1898.

Bulletin No. 70. Construction of Cheese Curing Rooms for Maintaining Temperatures of 58 degrees to 68 degrees F. January, 1899.

Bulletin No. 71. Sugar Beet Investigations in Wisconsin During 1898. February, 1899.

Bulletin No. 72. Small Fruits in 1898. April, 1899.

Bulletin No. 73. Analyses of Licensed Commercial Fertilizers, 1899. April, 1899.

Bulletin No. 74. A Study of Dairy Salt. May, 1899.
Bulletin No. 75. Testing Cows at the Farm. October, 1899.
Bulletin No. 76. Noxious Weeds of Wisconsin. July, 1899.
Bulletin No. 77. Effects of the February Freeze of 1899 upon Nurseries and Fruit Plantations in the Northwest. August, 1899.
Bulletin No. 78. The History of a Tuberculous Herd of Cows. August, 1899.
Bulletin No. 79. Principles of Construction and Maintenance of Country Roads. September, 1899.
Bulletin No. 80. The Character and Treatment of Swamp or Humus Soil. January, 1900.
Bulletin No. 81. Analyses of Licensed Commercial Fertilizers, 1900. April, 1900.
Bulletin No. 82. Experiments in Grinding with Small Steel Feed Mills. April, 1900.
Bulletin No. 83. Silage, and the Construction of Modern Silos. May, 1900.
Bulletin No. 84. Bovine Tuberculosis in Wisconsin. March, 1901.
Bulletin No. 85. Development and Distribution of Nitrates and Other Soluble Salts in Cultivated Soils. March, 1901.
Bulletin No. 86. Analyses of Licensed Commercial Fertilizers. March, 1901.
Bulletin No. 87. Native Plums. April, 1901.
Special Bulletin. The Prevention of Oat Smut. March, 1901.
Special Bulletin. Canker Sore Mouth in Young Pigs. May, 1901.
Special Bulletin. Directions for Growing and Feeding Rape. May, 1901.

Reports and Bulletins Wanted.—We have many calls from public libraries and from colleges and experiment stations for copies of former reports and bulletins. The following are out of print and very much desired: Annual reports of the Agricultural Experiment Station, I and IV; Bulletins of the Agricultural Experiment Station (not Farmers' Institute), 1 to 11, inclusive; also 13 and 15.

Friends of the Station who are not keeping files of our publications are earnestly urged to return to us any copies they may have of the rare reports and bulletins. We will gladly pay a reasonable sum for any of the lacking numbers above noted. Readers should bear in mind that the documents asked for are Experiment Station bulletins and reports, and not bulletins of the Farmers' Institute, which is another branch of the Agricultural College.

THE BABCOCK MEDAL PRESENTATION

W. A. HENRY.

In 1899 the Wisconsin Legislature passed a Joint Resolution providing that a medal be presented to Doctor S. M. Babcock of the Station, in recognition of his services to the state. Governor Scofield appointed as a committee to provide a medal and to arrange for its presentation, John W. Whalen, the mover of the Joint Resolution, Ogden H. Fethers, of Janesville, a Regent of the University of Wisconsin, and John M. True, formerly a Regent of the University, and at this time Secretary of the State Board of Agriculture.

The committee secured competitive designs for the proposed medal from both European and American artists and after due consideration, chose the design submitted by Spink & Son, London, England, Makers of the royal seals.

This was the largest bronze medal ever struck in England up to that time, and for its execution special machinery was constructed. It is of golden bronze, five inches in diameter. A reduced photographic reproduction of the medal faces the title page of this report. Upon the obverse are symbolical figures representing Agriculture and Science, bringing their offerings to the State, who sits enthroned on a raised dais. This is surrounded by the words "Wisconsin Legislature, 1899," and the arms of the state. The reverse contains the substance of the Joint Resolution:

"Recognizing the great value to the people of this state and to the whole world of the inventions and discoveries of Professor STEPHEN MOULTON BABCOCK *of the University of Wisconsin, and his unselfish dedication of these inventions to the public service."*

These words are surrounded by an oak wreath, and outside of all are the encircling words:

"The State of Wisconsin Presents to Professor Babcock this Medal."

On the evening of March 27, 1901, this medal was presented to Doctor Babcock in the Assembly Chamber at the Capitol, at a joint session of the Senate and Assembly, presided over by Governor Robert M. La Follette.

In his address Governor La Follette, among other things, said:

"In the midst of the spirit of commercialism in which we live surrounded by the sordid desire for wealth, its unscrupulous methods of attainment, its idolatrous worship, its unworthy power, such an example of pure-minded, honorable conduct, placing a public benefactor high in the confidence of the people, above all taint of suspicion, gives to the dedication of his invention to the public, even greater moral than money value and should make a profound and lasting impression upon the citizenship of the state. The acknowledgment of such an act is uplifting to the body politic, the state; it improves each community, affects each home, and inspires each individual.

"Wisely did the legislature provide and wisely has the committee executed in making permanent record of the people's appreciation of Professor Babcock's work for the state, and for the world; and in causing to be indelibly engraven in bronze, Wisconsin's recognition of his unselfish devotion to public service.

"This medal, formally presented to him tonight, can add nothing to his fame and reputation, for that is already world-wide. But the state, the legislature and the constituency back of this representative body, in thus expressing their appreciation of a great service, rendered in a spirit of noble generosity and high honor, will be inestimably benefited, in thus honoring Professor Babcock."

Other addresses were delivered by the following: C. W. Gilman, Assemblyman, representing the lower legislative branch; W. H. Hatton, Senator, representing the Senate; W. A. Henry, representing the University and its Experiment Station.

The presentation address was by Regent Ogden H. Fethers. In his address the symbolism of the medal was explained as follows:

"It represents the dignity of State, with Agriculture supported by Learning, beautifully united in a harmonious whole. Its excellence is enhanced by the relative dependence of each figure to the others, while

the imagination of the artist causes Agriculture and Learning to defer to State.

"State is seated on a throne of empire on the raised dais of supremacy. Behind her is anchored a ship of ancient make which has sailed out of the unenlightened yesterday. Expectantly and graciously she watches the advance of Agriculture, while in her left hand she holds the scroll which bears the record of your victory. Agriculture full of strength, triumphantly faces State and in the full knowledge of her achievements in science and invention places one foot securely upon the dais. On her arm she carries the ripened grain; one hand wields a sickle and the other is grasped by that of Learning. Together, they stand the splendid embodiment of the motto of Wisconsin—Forward. The imagination of the artist has created a grouping full of sentiment and throbbing with life.

"The inscription upon this enduring bronze will bear eternal witness that, 'Recognizing the great value to the people of this state and the whole world of the inventions and discoveries of Professor Stephen Moulton Babcock of the University of Wisconsin and his unselfish dedication of these inventions to the public service, the state of Wisconsin presents to Professor Babcock this medal.'"

Following Doctor Babcock's response came the address of the evening by W. D. Hoard, proprietor of Hoard's Dairymen, and ex-Governor of the Commonwealth. Of Doctor Babcock and his work Governor Hoard spoke:

"Wisconsin has had no lack of loyal and distinguished service from her sons in almost every branch of human effort. Starting in her statehood with a constitution of pofound wisdom, the work of almost matchless foresight, the name and renown of the state has been splendidly upheld and advanced on the battle field, in the work of state and national legislation, in the judiciary, by her inventors and great captains of industry, by her poets, her orators, and her schools, and not least by her farmers and teachers of agriculture. Loyalty, genius, courage, and enterprise are instinctive products of our soil and institutions. This occasion is in some respects, among the most notable in the history of our state. It is unique, and without precedent. It marks an epoch. It is full of inspiration for better things. It savors of the progress that maketh for peace, honor and good will among men.

"What is the central thought of this hour? It is to show in part what science has done for the world in the promotion of a knowledge of the truth in one of the greatest branches of American agriculture. 'The truth shall make you free,' said the Great Teacher. Ignorance is the mother of error. Error enslaves in everything and everywhere. It is in keeping with the central thought that we assemble here to do

honor to one of the most able and unselfish of all the noble band of missionaries which the scientific impulse of the age has sent out, to dispel ignorance and error, and establish a knowledge of the truth. It is beneath the dignity of this impressive occasion to indulge in fulsome laudation. The progress, the honor, the renown that Dr. Babcock has brought to Wisconsin is a greater characterization than I can make. 'Peace hath her victories, no less renowned than war.' Wisconsin does not forget that she hath her heroes as well. That lofty self abnegation of character which inspired the lowly Nazarene, and has inspired the heroic band of missionaries who have spoken for Him for two thousand years, finds wonderful parallel in the men who pursue scientific research for the sake of the truth they may find, and the good that truth shall do their fellow men."

Letters of congratulation from many distinguished parties were read, among others the following: James Wilson, Secretary of Agriculture, Washington; C. P. Goodrich, President Wisconsin State Dairymen's Association; Henry E. Alvord, Chief, Dairy Division, United States Department of Agriculture; I. P. Roberts, Professor of Agriculture, Cornell University; O. C. Gregg, Superintendent Farmers' Institutes, Minnesota; W. I. Buchanan, Director-General, Pan-American Exposition; James W. Robertson, Commissioner of Agriculture, Canada.

WHOLE CORN COMPARED WITH CORN MEAL FOR FATTENING SWINE.

W. A. HENRY.

The five previous reports of this Station have contained from one to two experiments each relative to the merits of whole corn and ground corn for fattening swine. Beginning in 1896 and each year since, a bunch of hogs has been divided into two equal lots, one getting whole corn and wheat middlings, and the other lot corn meal and wheat middlings. Records have been kept of the feed consumed, gains made, etc.

The trials here reported began November 17th, 1900, and continued twelve weeks. Owing to a breaking down of some of the hogs the results of the first week on the two feeds has not been rejected, as has usually been the case in our feeding trials, but is here included. The age of the pigs, sex and breeding are as follows:

LOT I.

No. of animal.	Age.		Sex.	Breeding.
	Months.	Days.		
1	7	17	Barrow	Grade Berkshire.
2	7	4	Sow	Grade Berkshire.
3	7	13	Barrow	Poland-China.
4	7	4	Sow	Grade Berkshire.
5	7	16	Barrow	Berkshire.
6	7	4	Barrow	Grade Berkshire.
7	8	2	Sow	Yorkshire.
8	6	12	Sow	Berkshire Razor-Back.
9	7	17	Barrow	Poland-China Razor-Back.
10	5	22	Sow	Berkshire.
11	6	1	Sow	Poland-China.
12	7	13	Barrow	Poland-China.

LOT II.

No. of animal.	Age.		Sex.	Breeding.
	Months.	Days.		
1	7	17	Barrow	Grade Berkshire.
2	7	17	Sow	Grade Berkshire.
3	6	29	Sow	Poland-China.
4	7	4	Barrow	Grade Berkshire.
5	6	29	Barrow	Poland-China.
6	7	17	Sow	Grade Berkshire.
7	6	16	Barrow	Poland-China.
8	7	17	Sow	Poland-China Razor-Back.
9	6	12	Sow	Berkshire Razor-Back.
10	8	2	Sow	Yorkshire.
11	6	12	Barrow	Berkshire Razor-Back.
12	7	6	Sow	Berkshire.

The hogs denoted "Razor-back" crosses had the blood of Indian territory feral or "wild" hog in them. Those not noted as grades or cross-breds were pure-bred animals eligible to registry. Previous to the experiment they had been variously fed grain, rape, etc. The corn used in this experiment was No. 3 old yellow Dent, grown in the vicinity of Madison. It contained, by chemical analysis, 11.47% water. The low water content shows that the corn was very dry.

Lot I received a ration consisting of two-thirds whole corn and one-third wheat middlings. It was recognized that the pigs could not be successfully fed many weeks on corn alone, and we followed our custom of previous years in supplying wheat middlings as a part of the ration. To the hogs getting whole corn the middlings was fed as slop and later the corn was placed in the same trough. The hogs getting ground corn were given corn meal and middlings mixed, with water added to form a slop. Both lots were fed twice daily. All were given salt, ashes and water in addition to the grain allowance. The following tables show feed given, the weight of each hog at the beginning of the trial, the weekly gains or losses of each individual, and the totals.

LOT I.— *Fed whole corn and middlings.*

	Feed Eaten, Lbs.		Weight and Gain, Lbs.												Total, Lbs.
	Whole Corn.	Mid-dlings.	B.* 1	S.† 2	B. 3	S. 4	B. 5	B. 6	S. 7	S. 8	B. 9	S. 10	S. 11	B. 12	
Wt. at beginning, Nov. 17	....	....	163	137	121	172	146	167	124	111	202	123	122	148	1,736
Feed and gain, 1st week	285	142	22	15	10	27	15	10	11	13	8	18	14	16	179
Feed and gain, 2d week	320	160	10	2	4	—5	6	8	7	3	8	5	5	4	57
Feed and gain, 3d week	326	163	5	7	7	11	8	6	9	13	12	4	13	12	107
Feed and gain, 4th week	340	170	9	10	1	2	7	8	2	5	7	6	6	6	69
Feed and gain, 5th week	325	163	11	13	13	25	8	11	7	8	13	16	13	10	148
Feed and gain, 6th week	303	154	8	9	2	5	—3	1	6	7	7	6	8	—16	35
Feed and gain, 7th week	290	145	3	1	0	—1	7	2	2	2	—5	7	2	21	41
Feed and gain, 8th week	288	144	9	6	2	4	0	10	8	1	6	0	7	2	55
Feed and gain, 9th week	284	142	5	8	—8	8	7	5	8	5	5	11	2	7	63
Feed and gain, 10th week	252	126	6	6	—7	4	0	5	7	6	11	8	4	—1	49
Feed and gain, 11th week	260	130	2	4	0	11	3	5	6	0	2	—7	—1	4	29
Feed and gain, 12th week	226	113	7	—4	5	12	2	9	7	8	10	13	—2	—6	61
Final weight	....	....	245	214	150	275	206	247	204	182	286	210	193	207	2,629
Feed eaten and gains	3,504	1,752	92	77	29	103	60	80	80	71	84	87	71	59	893

* B = barrow; † S = sow.

LOT II.—*Fed ground corn and middlings.*

	Feed Eaten, Lbs.		Weight and Gain, Lbs.												Total Lbs.
	Ground corn.	Mid-dlings.	B.* 1	S.† 2	S. 3	B. 4	B. 5	S. 6	B. 7	S. 8	S. 9	S. 10	B. 11	S. 12	
Wt. at beginning, Nov. 17	....	....	212	155	129	132	127	176	119	190	105	145	154	133	1,777
Feed and gain, 1st week	293	146	14	12	13	14	15	17	11	20	13	15	11	13	168
Feed and gain, 2d week	310	170	5	3	3	4	8	6	0	4	5	3	6	7	54
Feed and gain, 3d week	350	175	14	12	11	6	10	11	11	11	9	8	9	15	127
Feed and gain, 4th week	360	178	16	10	16	10	11	11	7	11	12	3	17	5	129
Feed and gain, 5th week	361	181	13	12	1	14	14	15	10	17	8	6	12	7	129
Feed and gain, 6th week	356	178	12	9	4	7	8	8	0	5	11	9	9	12	94
Feed and gain, 7th week	317	159	6	8	3	3	0	6	0	2	—6	10	2	—3	31
Feed and gain, 8th week	312	156	11	2	0	9	5	5	0	7	10	—2	9	4	60
Feed and gain, 9th week	302	151	6	3	3	3	4	6	0	4	9	13	5	6	62
Feed and gain, 10th week	302	151	11	6	2	8	0	13	—4	3	0	5	12	11	67
Feed and gain, 11th week	308	154	11	6	1	8	—3	9	—2	9	1	—6	6	7	47
Feed and gain, 12th week	230	115	14	12	—2	12	—8	6	—3	5	3	17	11	3	70
Final weight	....	....	345	250	184	230	191	289	149	288	180	226	263	220	2,815
Feed eaten and gains	3,831	1,914	133	95	55	98	64	113	30	98	75	81	109	87	1,038

* B = barrow; † S = sow.

The Poland-China hogs proved unsatisfactory feeders, showing losses at the weighing period on several occasions. Toward the last they became lame and their condition may be characterized as "broken down." As they had received the same treatment at all times as the others, we can not offer any explanation excepting that they were weaker animals generally.

A summary of this trial is as follows:

Feeding fattening hogs whole corn versus corn meal.

	Lot I. Whole corn.	Lot II. Cornmeal.
Average weight at beginning	145	148
Total feed eaten	5,256	5,745
Total gain	893	1,038
Feed for 100 lbs. of gain	588	553

From the data we learn that:

Lot I required 588 pounds of shelled corn and middlings (two-thirds shelled corn and one-third wheat middlings) to produce one hundred pounds of gain, live weight.

Lot II required 553 pounds of corn meal and middlings (two-thirds corn meal and one-third wheat middlings) for 100 pounds of gain, live weight.

This shows a saving by grinding of 35 pounds of corn on 588, or 6 per cent.

It will be noted that the meal-fed hogs made heavier gains than did those getting whole corn; but they also ate more feed. Thus it turns out that the advantage of feeding corn meal was not so great as would appear if only gains are considered. This explains in part at least why farmers are generally so favorably inclined to the use of ground corn for fattening hogs. They observe that hogs fed corn meal gain more rapidly than when fed whole corn, and consequently reach a given weight at an earlier date. Since farmers rarely weigh the feed given their hogs, they do not realize that the hogs getting corn meal also eat more feed than they would in the same time had they been fed whole corn. Only by weighing both animals and the feed they consume at stated periods can the real value of any given feed be ascertained.

RESULTS OF SIX YEARS' TRIALS.

We have now conducted experiments during six winters to determine the relative merits of ground and unground corn for fattening hogs. During this time 192 animals have been on trial. In all cases some wheat middlings have been fed with the corn as a part of the ration. The results of these six years' studies are summarized in the following table:

Results of feeding whole corn versus corn meal to 192 fattening hogs.

Report.	No of pigs in each lot.	Average weight at beginning.	Condition at beginning.	Per cent. saved or lost.	
1896........	9	350	Thin	8.0	Saved by grinding.
1896........	10	224	Fat...........	17.6	Saved by grinding.
1897........	9	211	Rather fat...	11.0	Saved by grinding.
1897........	7	190	Rather fat...	9.0	Lost by grinding.
1898........	8	185	Rather fat...	5.4	Saved by grinding.
1898........	8	184	Rather fat...	8.4	Saved by grinding.
1899........	19	186	Rather fat ..	2.0	Lost by grinding.
1900........	14	175	Rather fat...	15.0	Saved by grinding.
1901........	12	146	Rather fat...	6 0	Saved by grinding.

From the above it will be seen that in seven cases there was a saving through grinding the corn to meal, while in two cases there was a loss. The highest saving was 17.6 per cent., and the lowest 6 per cent. The highest loss was 9 per cent., and the lowest 2 per cent. In the above no allowance has been made for cost of grinding, the experiment being based entirely upon the gain or loss incurred while feeding.

THE COMPARATIVE VALUE AND THE EFFECT UPON LAMB CROP OF FEEDING VARIOUS RATIONS TO EWES IN WINTER.

W. L. CARLYLE.

The conduct of the experiment here reported was the same in every way as the one described in the 17th annual report of this Station.

The object of this investigation, as stated in the above mentioned report, is to determine the effect upon the lamb crop and the comparative value for breeding ewes of feeding the following rations:

1. Corn fodder, corn stover, bran and oats.
2. Corn silage, corn stover, bran and oats.
3. Corn silage, hay, bran and oats.
4. Roots, hay, bran and oats.

Forty-eight breeding ewes of the Station's flock were available for this experiment this year and were divided as equally as possible with regard to age, size and breed, into four lots of twelve ewes each.

The same grain ration was given to all the ewes on the experiment. This consisted of one-half pound per head of bran and oats equal parts by weight, fed once daily.

Lot 1 received a ration of cut corn fodder and uncut corn stover in addition to their grain ration. The corn fodder was fully matured, containing a large percentage of ears. This was run through a feed cutter and fed to the ewes each morning and evening in their racks in the barn, 2 pounds per ewe being given daily, of which they refused varying amounts, as will be seen in tables given below. The ewes in this lot were allowed

the run of a small field every day where they were fed what they would eat of uncut corn stover.

The ewes in lot 2 were fed 3 pounds corn silage each in their racks morning and evening, and the same amount of uncut corn stover in their fields as was given lot 1. The amount of silage was increased toward the close of the experiment, as the ewes were found to be losing in weight.

The ewes in lot 3 received three pounds each of corn silage in their racks in two feeds and two pounds each of early cut blue grass hay in the open field each day.

Those in lot 4 were fed three pounds each of pulped sugar beets in the barns and three pounds of the blue grass hay in their field each day.

The corn fodder and corn silage fed lots 1, 2 and 3, respectively, contained approximately the same amount of ear corn.

The amount of ear corn in the corn fodder fed lot 1 was found to be 43 per cent. of its total weight. These ewes ate 1.5 pounds of this fodder each per day and were fed 1.6 pounds of corn stover. The ewes in lot 2 ate an average of 2.9 pounds per day of corn silage and were fed the same amount of corn stover as the ewes in lot 1. No account was taken of the amount of the stover refused in the fields. The ewes in lot 3 also ate 2.9 pounds of corn silage each per day and were fed 2 pounds each of blue grass hay. Lot 4 ate an average of 3 pounds of sugar beets per day and 3 pounds each of blue grass hay. The ewes in lots 1 and 2 did not thrive as well on the feeds given them during the early part of the experiment as did the ewes in lots 3 and 4, consequently the amount of silage and corn stover fed daily was materially increased for lot 2 and the corn stover also to lot 1 during the latter part of the experiment.

COST OF DIFFERENT RATIONS FED.

The prices given the different feeds are purely arbitrary, but are such as prevail in the vicinity of Madison for the grain and hay. The roots, corn fodder, corn stover and corn silage are charged at about what it would cost to produce them. These prices were adopted last year for the experiment and were continued this year for comparison:

Hay (blue grass)	$ 5.00 per ton.
Oats	15.00 per ton.
Bran	14.00 per ton.
Roots (sugar beets)	3.00 per ton.
Corn stover	1.50 per ton.
Corn fodder	3.00 per ton.
Corn silage	1.50 per ton.

In estimating the cost per day of the various rations fed the different lots of ewes according to the above prices for feed-stuffs we find that the ration of roots, hay and grain fed lot 4 was the most expensive, costing 1.56 cents per head per day. Compared with this the ration fed ewes in lot 2, consisting of corn silage, corn stover, and grain was the cheapest, costing but .7 of a cent per ewe per day. The ewes in lot 1 receiving a ration of corn fodder, corn stover and grain, cost about the same as lot 2, viz.: .71 of a cent per ewe per day, while in lot 3 where the ration was corn silage, hay and grain the cost was 1.07 cents per ewe per day. From this it would seem that the hay and the roots were the two most expensive feeds used in this experiment, notwithstanding the fact that hay is priced at $5.00 per ton and the roots at $3.00 per ton, which is a low valuation on these feeds. It may be that the amount of corn fodder and corn silage refused by lots 1, 2 and 3 should be charged against them, as the portions refused were the coarse stalks that would never be eaten under ordinary circumstances, while all of the roots and practically all of the hay was consumed by lots 3 and 4.

A study of the tables given will show that the ewes in lot 1 refused 489.5 pounds of the corn fodder, while those in lot 2 refused 195.75 pounds of corn silage and those in lot 3 refused 114 pounds of the silage fed them. If these amounts be charged against the various lots it will be found that the ration fed lot 1 would cost for each ewe daily .78 of a cent, the ration for each ewe in lot 2 would cost .72 of a cent per day, and for lot 3, 1.08 cents per ewe per day.

GAIN AND WEIGHT OF EWES.

It would naturally be expected that ewes in lamb would increase somewhat in weight during the twelve weeks immediately preceding their lambing period. The individual ewes in all the

lots were weighed at the beginning and the close, and at intervals of two weeks during the experiment. In lots 1 and 4 the ewes made constant gains throughout the whole twelve weeks, while in lot 2 most of the ewes lost steadily in weight during the first eight weeks of the experiment, after which the amount of corn silage was increased one-half pound per head daily, when they steadily increased in live weight. The average gain of each ewe during the twelve weeks of the experimnt was 10.5 pounds, or approximately one pound each per week.

Tables showing the amount of the different kinds of feed eaten and the amount of gain made by the ewes in each lot.

LOT I.—*12 ewes. Cut corn fodder, uncut corn stover, bran and oats.*

DATE.	Grain, oats and bran.	CUT CORN FODDER.			Uncut corn stover.	Weight, gain and total cost.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Dec. 21	....	....	....	....	....	1,717
Dec. 28	42	168	57	111	123.2	6
Jan. 4	42	168	54	114	123.2	7
Jan. 11	42	168	44	124	123.2	....
Jan. 18	42	168	42	126	123.2	5
Jan. 25	42	168	34.5	133.5	123 2	....
Feb. 1	42	168	29	139	123.2	21
Feb. 8	42	168	34.5	133.5	154	....
Feb. 15	42	168	35	133	154	39
Feb. 22	42	168	38.5	129.5	154	....
Mar. 1	42	168	35	133	154	33
Mar. 8	42	168	45	123	154	....
Mar. 15	42	168	41	127	154	29
Total feed and gain	504	2,016	489.5	1,526.5	1,663.2	140
Cost of feed	$3.65	....	$.73	$2.29	$1.25	$7.92

LOT II.—*12 ewes. Corn silage, uncut corn stover, bran and oats.*

DATE.	Grain, bran and oats.	CORN SILAGE.			Uncut corn stover.	Weight, gain and total cost.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Dec. 21	....	....	....	....	....	1,659
Dec. 28	42	252	19	233	123.2	—23
Jan. 4	42	252	8.5	243.5	123·2	21
Jan. 11	42	252	11.25	240.75	123.2	....
Jan. 18	42	252	13	239	123.2	—16
Jan. 25	42	252	9	243	123.2	....
Feb. 1	42	252	6.25	245.75	123.2	—4
Feb. 8	42	252	3.5	248.5	154	....
Feb. 15	42	252	7	245	154	—15
Feb. 22	42	288	15.5	272.5	154	....
Mar. 1	42	294	16	278	154	61
Mar. 8	42	294	35.5	258.5	154	....
Mar. 15	42	294	51.25	242.75	154	9
Total feed and gain	504	3,186	195.75	2,990.25	1,663.2	33
Cost of feed	$3.65	....	$.15	$2.24	$1.25	$7.92

LOT III.—*12 ewes. Corn silage, hay, bran and oats.*

DATE.	Grain, bran and oats.	CORN SILAGE.			Blue-grass hay,	Weight, gain and total cost.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Dec. 21	....	....	....	....	....	1,793
Dec. 28	42	252	21.5	230.5	168	—18
Jan. 4	42	252	10	242	168	29
Jan. 11	42	252	12.25	239.75	168	....
Jan. 18	42	252	12.5	239.5	168	19
Jan. 25	42	252	10	242	168	....
Feb. 1	42	252	11.5	240.5	168	37
Feb. 8	42	252	4.25	247.75	168	....
Feb. 15	42	252	3.25	218.75	168	11
Feb. 22	42	252	2.25	249.75	168	....
Mar. 1	42	252	2	250	168	30
Mar. 8	42	252	7.5	244.5	168	....
Mar. 15	42	252	17	235	168	48
Total feed and gain	504	3,024	114	2,910	2,016	156
Cost of feed	$3.65	....	$.085	$2.18	$5.04	$10.95

LOT IV.—*12 ewes. Roots, hay, bran and oats.*

DATE.	Grain, bran and oats.	ROOTS. (SUGAR BEETS.)			Blue-grass hay.	Weight, gain and total cost.
		Given.	Refused.	Eaten.		
	Lbs.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.
Dec. 21	....	....	....	....	....	1,710
Dec. 28	42	252	....	252	252	13
Jan. 4	42	252	....	252	252	11
Jan. 11	42	252	....	252	252	....
Jan. 18	42	252	....	252	252	21
Jan. 25	42	252	....	252	252	....
Feb. 1	42	252	....	252	252	24
Feb. 8	42	252	....	252	252	....
Feb. 15	42	252	....	252	252	37
Feb. 22	42	252	....	252	252	....
Mar. 1	42	252	....	252	252	21
Mar. 8	42	252	....	252	252	....
Mar. 15	42	252	....	252	252	48
Total feed and gain	504	3,024	....	3,024	3,024	175
Cost of feed	$3.65	....	....	$4.55	$7.56	$15.76

EFFECT UPON LAMBS.

The details of the experiment as to the effect upon length of gestation period, vitality and weight of lambs at birth, milk supply of ewes, etc., are given in the following tables. From these it will be seen that the average period of gestation of all the ewes was 147.7 days and that no particular lot in the experiment varied appreciably from this period. A comparison of the periods of gestation of all the ewes on the experiment

that had strong lambs with those that dropped medium or weak lambs is more interesting; we find here that the average period of gestation of the ewes that dropped weak lambs was 149 days; in those ewes that dropped medium lambs the period was 148 days, while in those that dropped strong and vigorous lambs the period was 147 days.

A glance at the tables will also show that the number of lambs produced by the different lots of ewes varied somewhat but not as much as the tables would indicate at first sight, as there were two ewes in lot 1 and one ewe in lot 2 that failed to produce lambs. This leaves the percentage of increase the same in lot 1, where only ten ewes dropped lambs, as in lot 4 where twelve ewes dropped lambs, and that the percentage of increase was approximately the same in lots 2 and 3 where 11 and 12 ewes, respectively, were pregnant, but if we compare the percentage of increase of lots 2 and 3 with that of lots 1 and 4, we find that the lots 2 and 3 receiving the ration containing corn silage, have a percentage of increase of 1.52, while lots 1 and 4 that received the rations of corn fodder and roots in place of the silage have a percentage of increase of 1.77. Be it remembered, however, that this is from the standpoint of numbers alone, leaving out of consideration the individual vitality and size of the lambs in the different lots. When these are considered we find that the ten ewes in lot 1 dropped a total of 18 lambs, weighing on the average 7.05 pounds each, and that four were born dead, two were very weak at birth, two were of medium strength and ten were strong. In lot 2 the eleven ewes dropped 16 lambs, with an average weight at birth of 8.82 pounds, and that thirteen of these lambs were strong and three of medium strength at birth. The twelve ewes in lot 3 dropped 19 lambs of an average weight at birth of 7.98 pounds, and of this number 11 were strong, six of medium strength and two were weak. In lot 4 the twelve ewes dropped 21 lambs, with an average weight at birth of 7.51 pounds, and of this number 13 were strong, 4 were of medium strength, and 4 weak at birth. In this lot there were three lambs that were badly affected with goitre, an enlargement of the thyroid glands in the throat.

Tables giving the effects of different rations on the production of lambs.

LOT I.—Cut corn fodder, corn stover, bran and oats.

No. of ewe	Breeding.	Period of gestation, days.	Milk supply of ewe at parturition.	Weight and number of lambs.	Total weight	Strength of lamb at birth.
7	3d cross Shrop-Merino.	147	Very poor..	10.7	10.7	Born dead.
14	2d cross Dorset	144	Poor	4.8	4.8	Weak.
37	3d cross Shrop-Merino.	143	Good.......	6.4— 6.4	12 8	Medium.
49	2d cross Shrop-Merino.	147	Poor	6 — 5.5	11.5	Strong.
55	Southdown	149	Fair........	5.3— 5.6	10.9	1 dead, 1 weak.
294	Merino..................	Barren.				
1823	3d cross Shrop-Merino.	146	Poor	6.5— 5.4—6	17.9	Strong.
1832	Grade Shropshire	Barren.				
1870	Grade Dorset...........	150	Poor	10.1—10.6	20.7	Strong.
1902	Grade Shropshire......	148	Poor	8.8	8.8	Strong.
1910	Grade Shropshire......	157	Very poor..	5.8— 5.8	11.6	Born dead.
1961	Grade Shropshire......	147	Poor	9 — 8.2	17.2	Strong.

Average weight of lambs in this lot is 7.05 lbs.

LOT II.—Corn silage, corn fodder, bran and oats.

No. of ewe	Breeding.	Period of gestation, days.	Milk supply of ewe at parturition.	Number and weight of lambs.	Total weight	Strength of lambs at birth.
13	Grade Shropshire	151	Good	9.4	9.4	Strong.
33	Grade Shropshire	144	Fair........	9.7	9.7	Strong.
52	1st cross Shrop-Merino.	150	Good	11.6	11.6	Medium.
1360	2d cross Shrop-Merino..	146	Fair........	11.2	11.2	Strong.
1827	Grade Shropshire......	151	Fair........	8.6— 9.5	18.1	Strong.
1858	Southdown	146	Good	6.9— 6.9	13.8	Strong.
1914	Grade Shropshire	154	Fair........	7.6— 7.9	15.5	Medium.
1921	Grade Shropsnire	Barren.				
1951	2d cross Dorset	146	Poor	10.8	10.8	Strong.
1959	Grade Shropshire	146	Good	8.7— 7.7	16.4	Strong.
1965	2d cross Dorset.........	145	Fair........	10.2	10.2	Strong.
1968	Grade Shropshire	145	Poor	7.3— 7.2	14.5	Strong.

Average weight of lambs in this lot is 8.82 lbs.

LOT III.—Corn silage, hay, bran and oats.

No. of ewe	Breeding.	Period of gestation, days.	Milk supply of ewe at parturition.	Number and weight of lambs.	Total weight	Strength of lambs at birth.
23	Grade Shropshire	147	Good.......	11.5	11.5	Strong.
28	3d cross Shrop-Merino.	144	Good.......	4.5—6	10.5	Weak.
334	Merino..................	150	Good.......	11.2	11.2	Strong.
1469	Southdown	150	Very good..	8.1—9 2	17.3	Strong.
1516	Grade Shropshire	146	Very good..	8 —6.4	14.4	Strong.
1554	Grade Shropshire	148	Fair........	7.3—6.3	13.6	Medium.
1831	Grade Shropshire	146	Good.......	10.6	10.6	Strong.
1859	Southdown	149	Very good..	9.8	9.8	Strong.
1907	3d cross Shrop-Merino .	148	Good.......	8.6	8 6	Strong.
1953	2d cross Dorset.........	147	Good.......	7.7—7.9	15.6	Strong.
1960	2d cross Shrop-Merino	149	Poor	8 —5.6	13.6	Medium.
1963	2d cross Dorset.	146	Good.......	7.9—7	14.9	Medium.

Average weight of lambs in this lot is 7.98 lbs.

LOT IV.—Roots, hay, bran and oats.

No. of ewe	Breeding.	Period of gestation, days.	Milk supply of ewe at parturition.	Number and weight of lambs.	Total weight	Strength of lambs at birth.
8	3d cross Shrop-Merino..	150	Very good..	9.7	9.7	Weak.
46	2d cross Dorset.........	144	Very good..	7.1—6.7	13.8	Strong.
56	Southdown	151	Good.......	6.4	6.4	Weak.
293	Merino	149	Poor	7.2—6.4	13.6	Strong.
1328	Grade Dorset...	145	Good.	10.8	10.8	Strong.
1352	1st cross Shrop-Merino.	150	Fair........	9.7—	9.7	Strong.
1455	Grade Shropshire	148	Fair........	7 —6.9—5.3	19.2	Medium.
1468	2d cross Shrop-Merino..	146	Fair........	8.7—7 3—6.1	22.1	Strong.
1472	Grade Dorset...........	147	Good	7.4—7.2	14.6	Strong.
1546	Grade Shropshire	146	Fair........	9.6—8.5	18.1	Strong.
1920	Grade Shropshire	147	Poor	7.4—5.8	13.2	Weak.
1958	Grade Shropshire	151	Poor	6.6	6.6	Weak.

Average weight of lambs in this lot is 7.5 lbs.

SUMMARY.

1. From this experiment it would seem that corn fodder, corn stover and 1-2 pound of equal parts bran and oats per ewe per day for 12 weeks before lambing was a satisfactory food so far as the physical condition of the ewes was concerned until lambing period arrived, when there was a marked deficiency in the milk secretion as compared with the ewes in the other lots. We further find that the lambs by the ewes fed these feeds were smaller in size and a larger proportion of weak and dead ones at birth than in the other lots.

2. Corn stover and corn silage with 1-2 pound per ewe daily of bran and oats was found to be a most satisfactory ration in every respect for breeding ewes bearing lambs. The ewes were healthy, a good supply of milk in their udders at lambing time, and the lambs were of good size, strong and vigorous at birth.

3. A ration composed of corn silage, hay, and the grain mixture was equally as satisfactory in every way as the ration composed of corn stover and corn silage.

4. A ration of roots and hay with the grain mixture was not as satisfactory as the rations containing corn silage, but gave better results than the ration of corn stover and corn silage. Many of the ewes did not have a satisfactory milk supply at lambing time and a number of the lambs were weak and goitered.

5. With conditions as given in this experiment we find the rations of corn fodder, corn stover, and corn silage to be the cheapest and the ration containing roots and hay the most expensive ration fed. Where the roots and hay were combined in the same ration the cost was approximately double that where the ewes were fed on silage and corn fodder or corn stover and corn fodder.

6. From this experiment and the one reported last year (see page 28, 17th Annual Report) we conclude that corn silage is one of the cheapest and most satisfactory foods for breeding ewes in winter and that a ration, the roughage of which is composed entirely of corn fodder, is not entirely satisfactory under same conditions.

EXPERIMENTS IN PIG FEEDING.

I. Effect of Feeding Various Grain Rations to Growing and Fattening Hogs.

W. L. CARLYLE AND T. F. McCONNELL.

The fourth, fifth, sixth, and the seventeenth Annual Reports of this Station present results of a number of experiments bearing on the comparative effect produced on the carcasses, bones, and viscera of growing and fattening hogs when fed various grain rations. The experiments here reported are a continuation of this work on the same general plan of those preceding them.

PLAN OF EXPERIMENT.

Ten pigs were chosen for the first experiment. These pigs were from four spring litters and represented four breeds, viz.: two were Berkshires, two Poland-Chinas, two Yorkshires and four were Cross-bred Razor-back Poland-Chinas. The Berkshires and Poland-Chinas fairly represented these well known breeds of swine. The Yorkshires were bred from stock imported from Canada of English breeding, representing the class of hogs so much used in Canada, England, and Denmark for the production of choice bacon. The Razor-back Poland-China crosses were got by a boar of the type generally known in the southern states as "Razor-back," this particular animal having been captured running wild in the woods with a herd of his kind in Indian Territory. He was bred to a fine-boned, short-bodied Poland-China sow, producing the above mentioned pigs. The accompanying cuts show photos of pigs taken just before slaughtering, selected as fairly representing the above mentioned breeds and crosses.

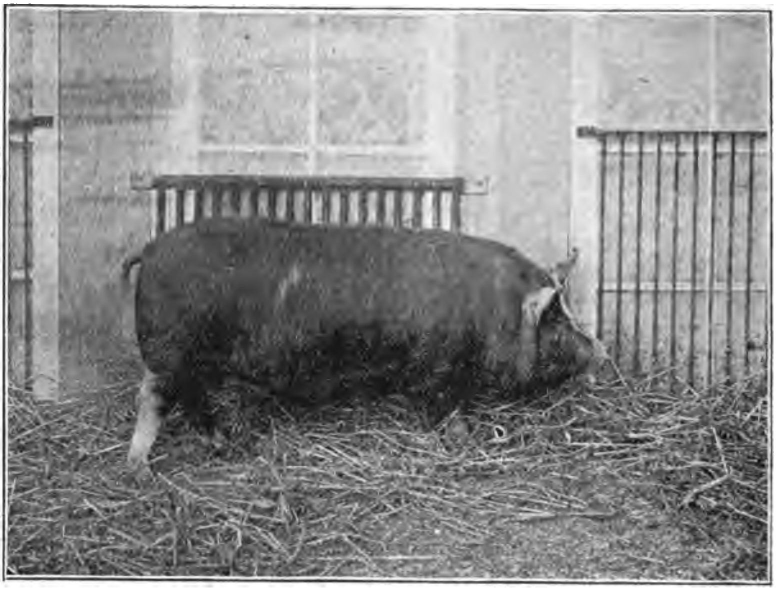

FIG. 1.—Represents the type of Poland China pigs in these experiments.

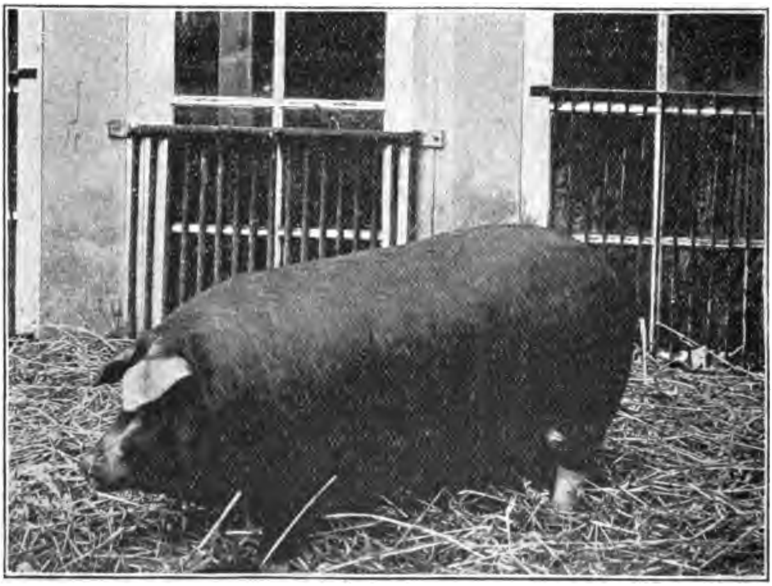

FIG. 2.—Represents the type of Berkshire pigs in these experiments.

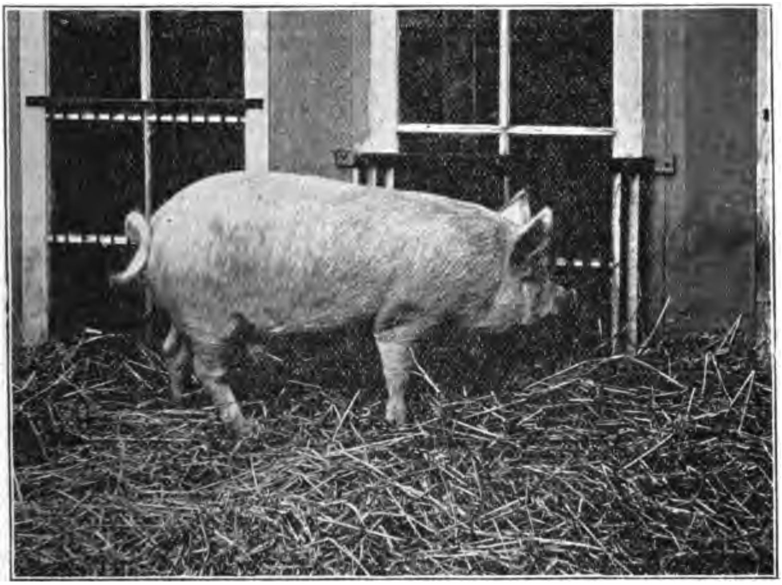

FIG. 3.—Represents the type of Improved Large Yorkshire pigs in the first experiment.

FIG. 4.—Represents the type of cross-bred Razor-Back Poland China pigs in these experiments.

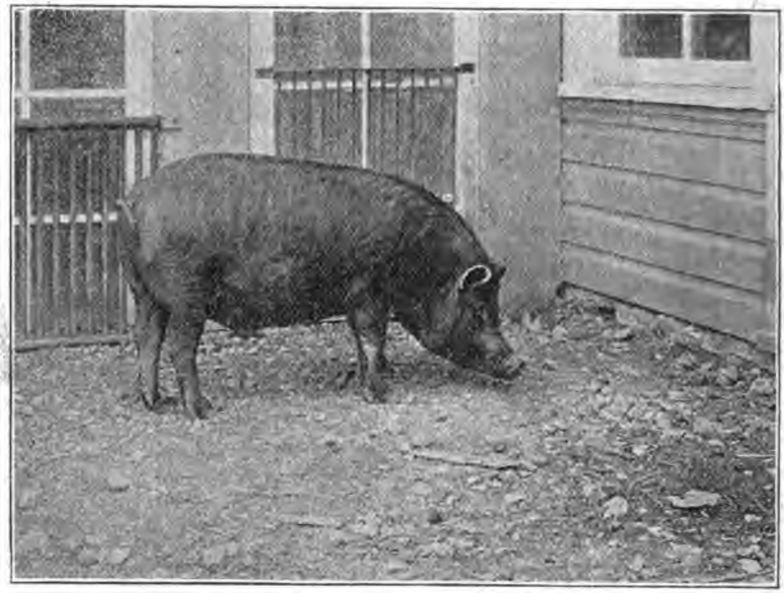

FIG. 5.—Represents the type of cross-bred Razor-Back Berkshire pigs in these experiments.

FIG. .—Represents the type of Razor-Back pigs in these experiments.

The age, record, number, breeding, sex, and initial weight of each one of the pigs on the experiment is given in Table No. 1. The pigs were divided into two lots as nearly equal in every way as possible, there being one Berkshire, one Poland-China, one Yorkshire and two Cross-bred pigs in each lot, selected in such a manner as to have an equal number of pigs from each litter in each of the lots. Pens with clay floors 12 feet square were provided for each lot in a comfortable house and each lot was also allowed the run of a small yard outside in which to get exercise. In these yards they were furnished a plentiful supply of coal ashes at all times, also having access to salt at will.

TABLE No. I.—*Data concerning pigs at the beginning of the experiment.*

LOT 1.—Corn meal and rye.

Record No.	Breed.	Number of dam.	Sex.	Age, days.	Weight, lbs.
162	Poland-China	1981	Barrow	184	131
114	Razor-back Poland.China	Quality	Sow	186	122
108	Razor-back Poland-China	Quality	Barrow	200	144
109	Yorkshire	1991	Sow	176	140
134	Berkshire	1975	Barrow	176	130

LOT 2.—Peas and shorts.

Record No.	Breed.	Number of dam.	Sex.	Age, days.	Weight, lbs.
137	Berkshire	1975	Brrrow	176	137
111	Yorkshire	1991	Barrow	176	117
116	Razor-back Poland-China	Quality	Barrow	186	154
163	Poland-China	1991	Barrow	184	127
115	Razor-back Poland-China	Quality	Sow	186	137

Each pig was fed separately by sub-dividing the feeding pens into small compartments, where they received a weighed allowance of feed three times daily. Careful records were kept of the amount of feed eaten and the gains made by each pig on the experiment, the pigs being weighed on a certain day in every week.

THE RATIONS FED.

The five pigs in lot 1 were fed a ration composed of equal parts of corn and rye, both grains being finely ground before feeding. The pigs in lot 2 were fed a ration of one-third peas

finely ground and two-thirds wheat shorts. The different grain mixtures were weighed out to each pig at each feeding time and only as much given as would be eaten readily. Water in sufficient quantities to make a thin slop was added to each feed just before placing it in the troughs.

TABLE No. II.—*Showing amount of feed eaten, initial weights, and gains in two-week periods.*

LOT I.—Corn meal and rye.

	114.		108.		134.		162.		109.		Total feed.	Total weight and gain.
	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs.
Weight at beginning	.....	122	.....	144	.....	130	.. .	131	.....	140	....	666
1st two weeks	58.8	13	77	24	77	23	77	21	63.2	21	353	102
2d two weeks	57.6	13	79	15	82.6	17	84	17	65.2	12	368.4	74
3d two weeks.	56.8	11	86.2	19	86.2	18	86.2	16	68	12	383.4	76
4th two weeks	62	12	88.4	15	88.4	17	88.4	17	70	9	397.2	70
5th two weeks	61	11	94.4	22	58.6	2	89.6	19	61.2	14	364.8	68
6th two weeks	61.6	.....	89.6	5	65	7	89.6	2	59.2	.....	365.0	14
Total feed and gain	357.8	60	514.6	100	457.8	74	514.8	92	386.8	68	2,231.8	404
Total weight....	.....	60	.....	100	....	214	.....	223	.....	208	....	1,071

LOT II.—Peas and shorts.

	137.		111.		116.		163.		115.		Total feed.	Total weight and gain.
	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.		
	Lbs.	Lbs	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs	Lbs.	Lbs.
Weight at beginning	.....	137	.....	113	.....	154	......	127	......	137	....	668
1st two weeks	67.2	23	52.5	12	81.3	20	72.9	23	60.3	16	334.2	94
2d two weeks	67.5	14	52.8	10	83.1	16	79.2	15	55.2	6	337.8	61
3d two weeks	72	7	54.6	2	78	6	78	− 2	53.7	11	336.3	24
4th two weeks	66.9	14	52.6	9	75.6	16	76.1	12	62.7	10	328.5	61
5th two weeks	61.05	− 2	.....	.....	71.7	− 9	76.35	4	66.75	− 3	275.85	−10
6th two weeks	48.6	12	.....	.....	66.6	.....	67.2	....	49.0	....	231.6	12
Total feed and gain.	383.25	68	212.5	33	466.3	49	449.75	52	347.65	40	1844.25	242
Total weight....	......	205	.....	146	.....	203	......	179	......	177	....	910

COMPARISON OF THE EFFECTS OF RATIONS FED ON RATE OF GAIN.

Table No. II given above shows the initial weight, the amount of grain eaten, and the gain made by each pig in two week periods during the experiment; also the final weights and the total gain of each pig and lot and the total amount of each kind of grain eaten. A study of these tables reveals a number of points that are of interest. It will be seen that there was a wide variation in the amounts of food consumed by the different pigs in both of the lots. It will also be noticed that the pigs in lot I, fed corn and rye, ate more feed daily than did the pigs in lot II getting peas and shorts, and that the gains were not only greater but also much more uniform and regular.

The pigs in both lots made the most rapid gains during the first weeks of the experiment, this being especially true of the lot fed peas and shorts, though there was a marked tendency to drop off in weekly gains in both lots as the experiment neared its close. The primary object of this experiment was not so much a comparison of the relative feeding values of the different rations fed as it was to note their effect on the carcass and internal organs of the hogs, yet in Table No. III a summary of the results of the experiment is given comparing the feeding values of the two rations which, while not conclusive, may be taken for what it is worth.

TABLE No. III.— *Summary of feed eaten and gain made by pigs.*

	Lot 1, Corn meal and rye.	Lot 2, Peas and shorts.
	Lbs.	Lbs.
Average amount of grain eaten per pig per day	5.3	4.68
Average gain of each pig per day	0.96	0.62
Average gain per pig for 84 days	80.8	48.4
Average amount of feed for 100 lbs. gain	552	762
Amount of digestible protein in 100 lbs. of feed	8.9	13.7
Amount of digestible carbohydrates in 100 lbs. of feed	67.1	50.6
Amount of digestible fat in 100 lbs. of feed	2.7	2.7
Amount of digestible protein for 100 lbs. of gain	49.13	104.39
Amount of digestible carbohydrates for 100 lbs. of gain	370.39	385.57
Amount of digestible fat for 100 lbs. of gain	14.90	20.57
Nutritive ratio	1 : 8.2	1 : 4.1

From this it will be seen that the pigs in lot I, receiving corn and rye, ate over one-half pound of feed and gained over one-third of a pound in live weight per pig per day more than did the pigs in lot 2 getting peas and shorts. That is to say, the lot getting corn and rye for food ate on the average 13.2 per cent. more food daily than did the pigs getting peas and shorts and gained 54.8 per cent. on the average more in live weight daily. While therefore it will be readily seen that the corn and rye fed lot ate more, they gave a much greater proportionate gain in live weight and consequently returned a much greater profit for food consumed. Attention is called to the great difference in the amounts of protein, carbohydrates, and fat in the rations fed the two lots, also to the nutritive ratios. It will be noticed that in the case of lot 1 the ratio of protein to carbohydrates is just double the ratio of these substances in the feeds fed lot II. Judging entirely from the results of this experiment it would appear that a feed containing a proportionately large amount of carbohydrates to protein was not only much more profitable, since the element of protein is the expensive one in all feeds, but that the feed containing a large proportion of carbohydrates and a small amount of protein was actually worth more pound for pound where rapid gains are desired in fattening pigs. If, however, a comparison be made between the nutritive ratios of the rations fed these two lots of pigs and the nutritive ratios of the German feeding standards for fattening hogs of this age and weight, it will be seen that the nutritive ratio is as much too wide in one case as it is too narrow in the other; or, in other words, the corn and rye ration contained as much too great a proportion of carbohydrates and fat to the protein content as the ration of peas and shorts did too little. The German standards give the nutritive ratio for pigs of this age and weight as containing 1 part protein to about 6 parts carbohydrates and fat, while in the case of these rations it was 1:8.2 in the corn and rye ration and 1:4.1 in the ration of peas and shorts. Attention will be called to this phase of this experiment in the discussion of the results of another, a report of which is given in the following pages.

A STUDY OF THE CARCASSES AND INTERNAL ORGANS.

The slaughter tests, etc., were conducted on practically the same lines as were described in the Seventeenth Annual Report, pp. 19. In studying the findings of the block tests, as given in the accompanying tables, Nos. IV and V, we notice quite a marked difference in favor of the lot fed corn and rye in the percentage of dressed meat to live weight. This fact would seem a point in favor of corn and rye as a ration for feeding hogs, especially when viewed from the standpoint of the packer. When, however, a little further study of the table discloses the fact that this increased percentage of dressed meat to live weight is the outcome of a proportionately smaller percentage of blood and heart, kidneys, liver, spleen, stomach, intestines, and other internal organs that have to do with the vital functions of the animal it may be that this increased percentage of dressed meat has been secured at the expense of the vitalizing forces of the animal, leaving it impoverished in those respects to a degree that may go far to explain the great prevalence of hog cholera and other diseases that are so common and so extremely fatal in those sections where the hogs are fed mainly corn.

One of the peculiarities to be noted in a study of these results is the slight difference between the thickness of outside fat on the carcasses of the hogs from the two lots when viewed from the standpoint of the number of inches to 100 pounds of dressed weight, while the difference in actual thickness of the fat on the carcasses from the two lots is quite pronounced. It would seem that it was quite important to notice this point since the average thickness of fat on the outside of the carcasses of one lot was 2.05 inches and of the other lot 1.6 inches, yet the proportional amount of outside fat to dressed carcass was very little greater in one lot than in the other. The photographs of each of the carcasses of the hogs on this experiment as they appear in the following pages show a marked contrast in the amount of lean meat or muscle in pigs fed the peas and shorts ration when compared with their litter brothers fed corn and rye. Attention is especially called to the comparative development in each one of the carcasses of the large muscle lying on each side of the spinal column.

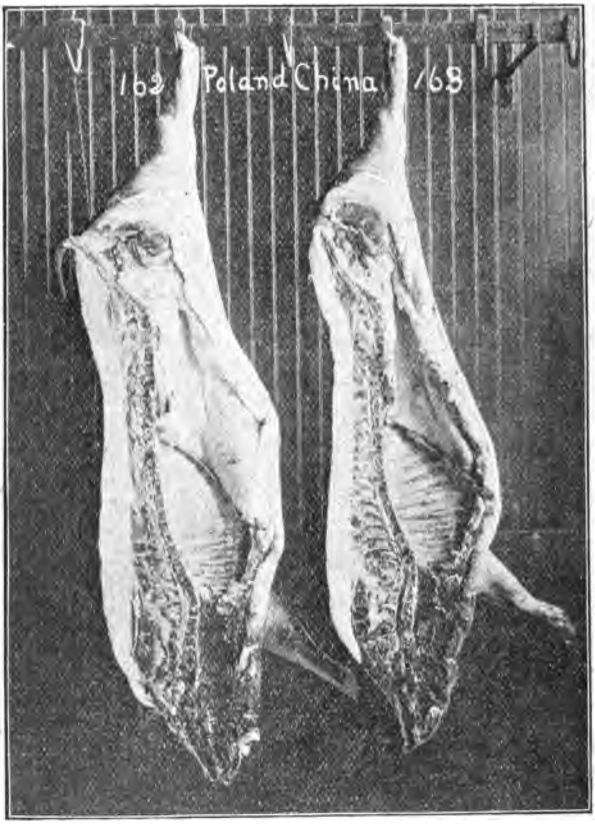

FIG. 7.—Showing carcasses of a pair of Poland China pigs, litter brothers, 162 fed corn and rye, and 163 fed peas and shorts. Note the proportion of lean meat to fat in the various parts of these two carcasses, especially the distribution of the fat between the muscles of the two pigs.

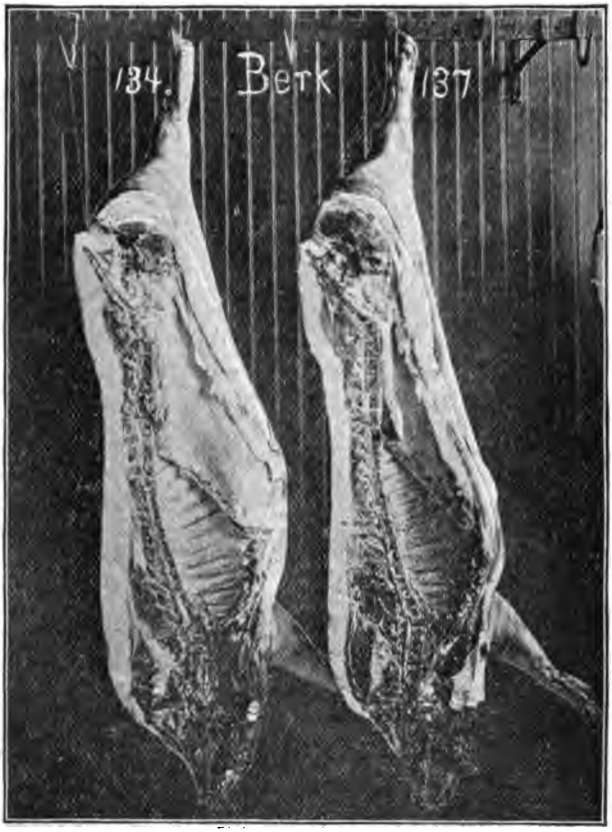

FIG. 8.—Showing vertical and cross-sections of a pair of Berkshire pigs, litter brothers, 134 fed corn and rye, and 137 fed peas and shorts. Note the large proportion of lean meat in the ham as shown in the vertical section and in the back and ribs as shown in the cross-section of the pig fed peas and shorts as compared with the one fed corn and rye.

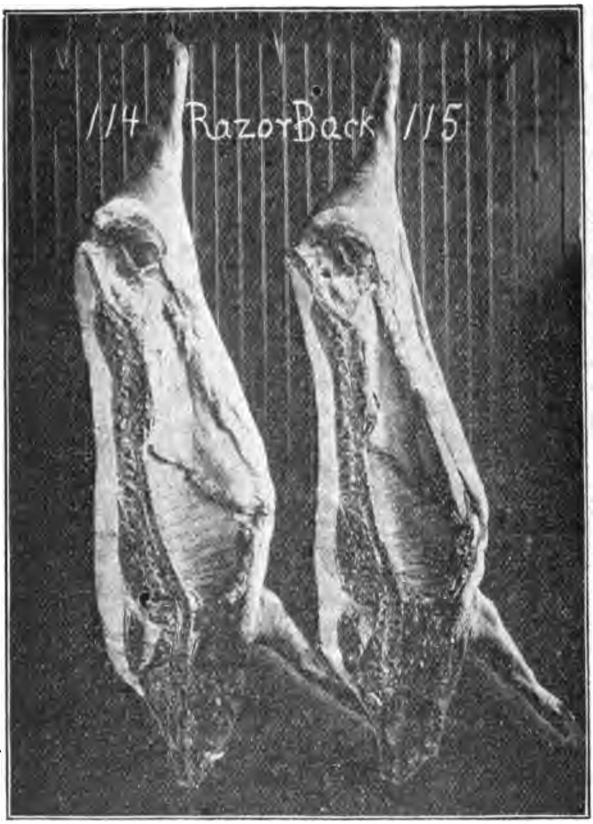

FIG. 9.—Showing carcasses of a pair of cross-bred Razor-back Poland-China pigs, litter brothers, 114 fed corn and rye and 115 fed peas and shorts. Note the very small proportion of lean meat in the hams of both these carcasses, also the proportion of lean meat to fat in the cross section.

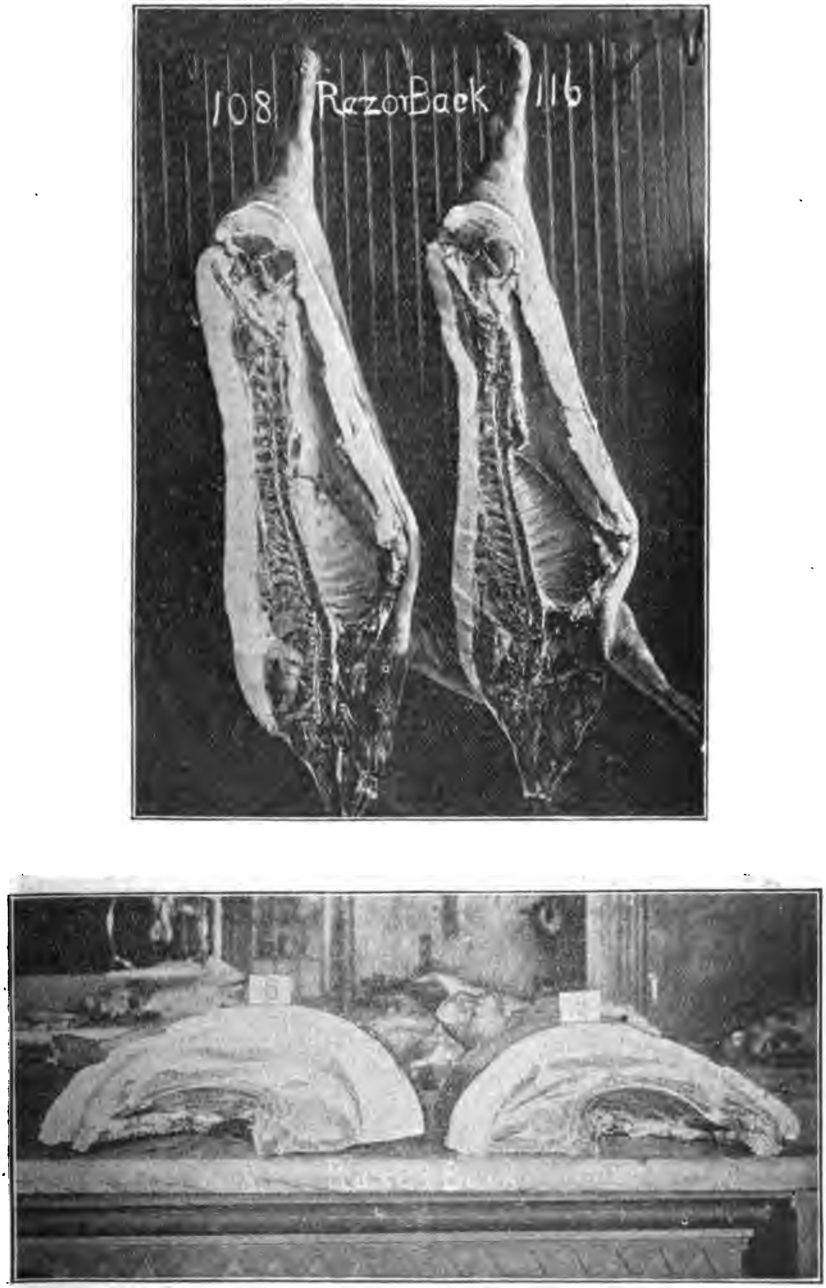

FIG. 10.—Showing carcasses of a pair of cross-bred Razor-back Poland-China pigs, litter brothers, 108 fed corn and rye, 116 fed peas and shorts. Note the very large proportion of fat meat in the carcass of the pig fed corn and rye.

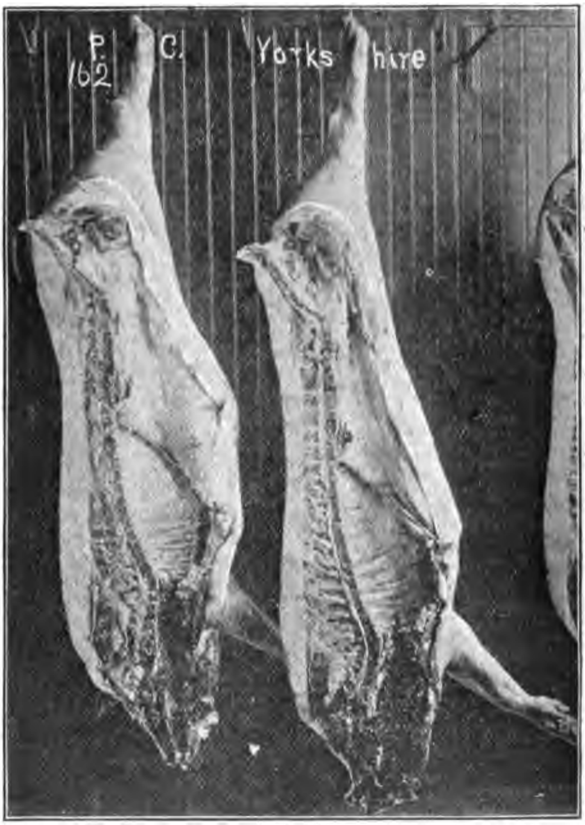

FIG. 11.—Showing carcasses of a Poland-China and of a Yorkshire pig, both having been fed corn and rye. Note the length of body of the Yorkshire as compared with the Poland-China, the proportion of lean meat to fat and the development and character of the hams in the two carcasses.

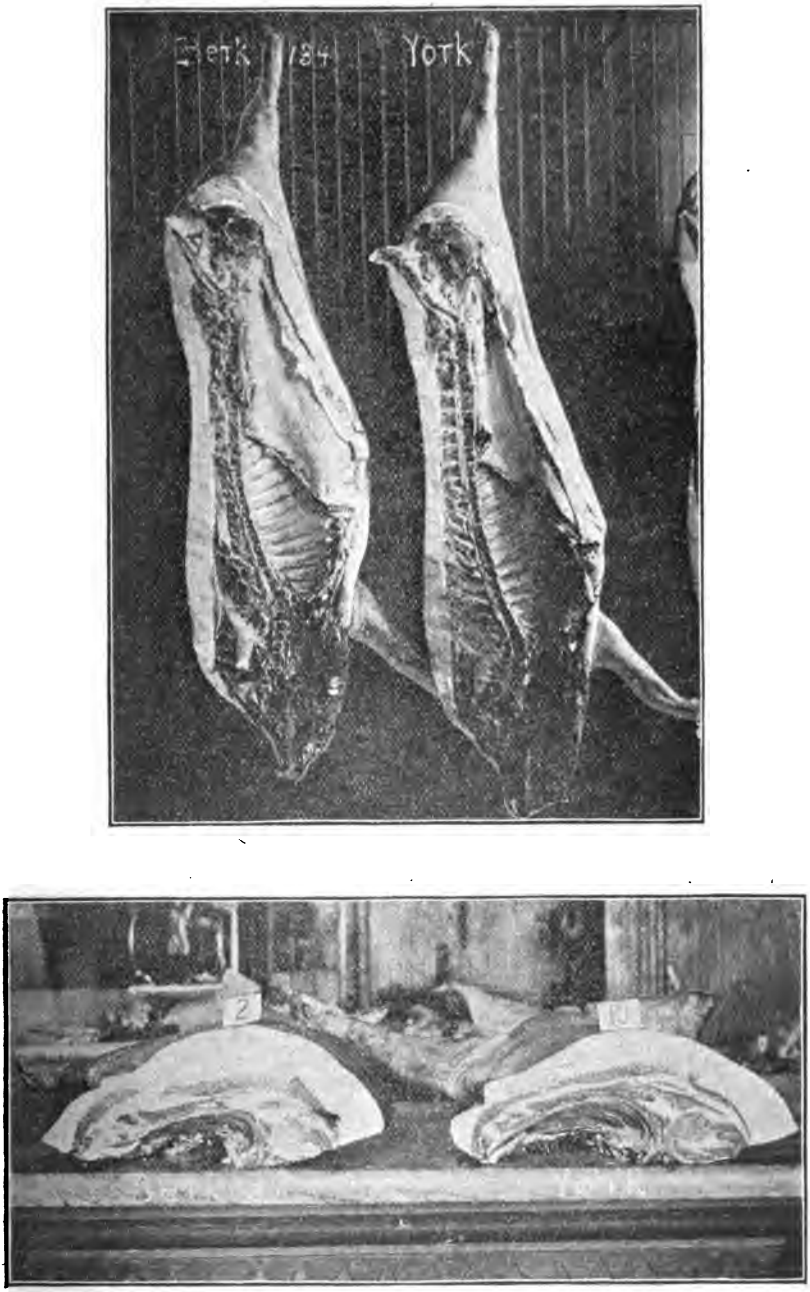

FIG. 12.—Showing carcasses of cross-bred Razor-back Poland-China and Yorkshire pigs, both fed corn and rye. Note the similarity in conformation of the hams and the difference in length of body of the two pigs.

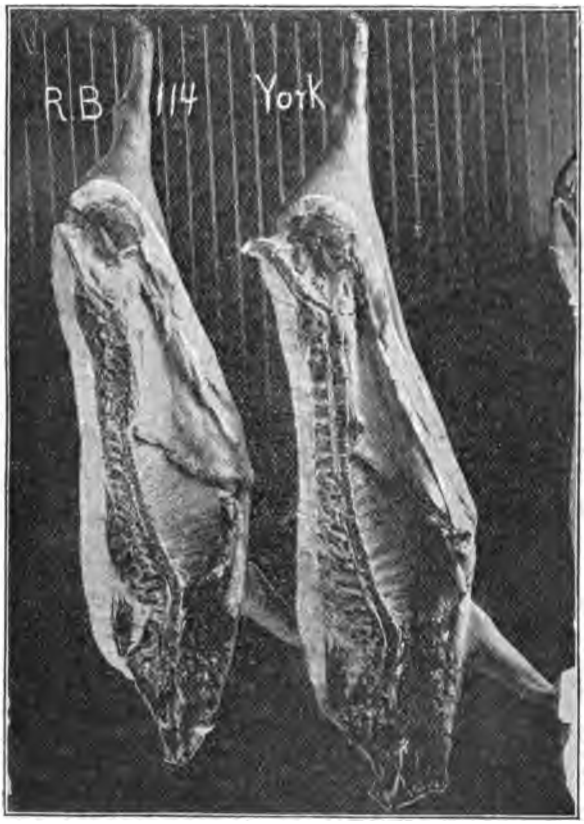

FIG. 13.—Showing carcasses of a Yorkshire and a Berkshire pig. both fed corn and rye. Compare the proportionate length of body to shoulders and hams in the two carcasses.

TABLE NO. IV.—*Weight of carcass and various organs of pigs fed a ration of peas and shorts in opposition to corn and rye.*

LOT 1.—Corn meal and rye.

Record number.	Breed.	Live weight	Dress weight.	Weight of blood.	Weight of intestines	Weight of spleen.	Weight of liver.	Weight of stomach.	Weight of heart.	Intestinal fat.	Kidney fat.	Length of small intestines.	Length of large intestines.	Length of body.	Weight of kidneys.	Thickness of fat on loin.	Thickness of fat on back.	Thickness of fat on shoulder.	Breaking strength of thigh bones.	Breaking strength of hind posterns.
		Lbs	Lbs.	Lbs.	Lbs.	Oz.	Lbs.	Lbs.	Oz	Lbs	Lbs.	In.	In.	In.	Oz.	In.	In.	In.	Lbs.	Lbs.
162	Poland-China	223	183	5.2	13.1	2.4	3.2	4.8	5.0	3.4	7.87	660	187.2	38.5	8.0	1.75	2.5	2.75	930	222
109	Yorkshire	208	162	5.4	17.3	4.0	3.0	5.6	8.0	2.8	6.0	634	196.8	39.5	6.0	1.37	1.5	2.25	886	175
131	Berkshire Razor-back..	214	175	4.9	13.6	3.2	2.7	3.1	8.0	2.7	8.5	615	180	33.0	8.0	1.75	2.12	2.37	748	277
108	Poland-China	241	195	6.4	17.5	4.8	3.5	4.2	9.6	2.7	9.0	681	168	......	10.0	1.75	2.5	3.00	1,050	384
114	Razor-back Pol.-China.	182	144	4.7	15.3	4.0	2.5	4.1	8.0	2.7	7.87	624	163	37.0	5.0	1.12	2.0	2.12	727	201
	Average	**214.2**	**171.8**	**5.32**	**16.76**	**3.8**	**2.98**	**4.36**	**8.32**	**2.68**	**7.84**	**653.4**	**180**	**33.2**	**7.4**	**1.54**	**2.12**	**2.49**	**868**	**254**

LOT 2.—Peas and shorts.

Record number.	Breed.	Live weight	Dress weight.	Weight of blood.	Weight of intestines	Weight of spleen.	Weight of liver.	Weight of stomach.	Weight of heart.	Intestinal fat.	Kidney fat.	Length of small intestines.	Length of large intestines.	Length of body.	Weight of kidneys.	Thickness of fat on loin.	Thickness of fat on back.	Thickness of fat on shoulder.	Breaking strength of thigh bones.	Breaking strength of hind posterns.
137	Berkshire	205	138	4.7	15.3	4.8	4.0	4.1	6.4	2.5	5.5	615	181.8	37.0	6.25	1.25	1.62	1.75	816	274
163	Poland China........	179	140	5.3	16.9	3.2	3.8	4.1	8.0	2.3	8.3	610.2	192	34.0	9.00	1.37	1.75	2.12	862	240
115	Razor-back Pol.-China.	177	133	5.4	18.1	3.2	3.1	4.6	6.4	2.7	6.5	607.2	181.8	33.5	8.00	0.88	1.62	2.00	762	174
116	Razor-back Pol. China.	203	152	6.2	21.0	4.8	3.8	5.7	8.8	3.8	9.37	732	204	38.0	16.00	1.25	1.75	2.00	859	303
	Average............	**191**	**145.6**	**5.4**	**16.57**	**4.0**	**3.66**	**4.62**	**7.4**	**2.82**	**.4 1**	**63.50**	**188.4**	**35.5**	**9.86**	**1.16**	**1.68**	**1.96**	**829**	**249**

Lbs. = Pounds. Oz. = Ounces. In. = Inches.

TABLE No. V.—*Amount of blood, liver, spleen, etc., for each 100 lbs. weight of carcass.*

LOT 1.—Corn meal and rye.

Record No.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kidneys.	Thickness outside fat.	Weight of kidney fat.	Intestinal fat.	Per cent. dressed.	Thigh bones.	Hind postern.
		lbs.	oz.	lbs.	oz.	oz.	in.	lbs.	lbs.		lbs.	
162	Poland-China	2.84	1.311	1.748	4.37	4.37	1.27	4.3	1.853	82.	508	126
109	Yorkshire....	3.33	2.44	1.85	4.938	3.703	1.05	3.703	1.728	77.8	546	108
131	Berkshire....	2.80	1.82	1.54	4.571	4.571	1.188	4 857	1.542	81.7	427	158
108	Razor-back Pol'd-China	3.28	2.461	1.794	4.923	5.128	1.233	4.615	1 384	79.9	538	195
114	Razor-back Pol'd China.	3.26	2.77	1.736	5 55	3.472	1.212	5.465	1.875	79.1	503	142
	Average.....	3 10	2.16	1.734	4.871	4.248	1.191	4.588	1.677	80.1	504	146

LOT 2.—Peas and shorts.

Record No.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kidneys.	Thickness outside fat.	Weight of kidney fat.	Intestinal fat.	Per cent. dressed.	Thigh bones.	Hind postern.
137	Berkshire....	2.97	3.037	2.531	4.05	3 955	.974	3.481	1 582	77.	516	173
163	Poland-China	3.78	2.285	2.714	5.714	6.428	1.217	5.923	1.642	78.2	615	171
115	Razer-back Pol'd-China.	4.06	2.406	2.33	4.812	6 015	1.123	4.887	2.03	75.1	576	131
116	Razor-back Pol'd-China.	4.08	3.157	2 5	4.789	10.526	1.096	6.164	2.5	74.8	565	201
	Average.....	3.72	2.721	2.519	5.091	6.731	1.111	5 115	1.938	76.2	568	169

A test of the strength of the bones and tendons of each of the pigs on the experiment was also undertaken. This was deemed important, inasmuch as many of the fat hogs marketed yearly in the United States, especially when shipped long distances, are very subject to broken bones and a crippled condition of the hind limbs. The thigh bones of each of the pigs were dissected out, and while yet fresh were subjected to a breaking test in a machine in the University Engineering building constructed for the purpose of testing the breaking strength of materials. In this machine the thigh bone was laid flat on two rounded iron edges placed four inches apart, the lower structure representing a common scale with a beam and weights. A third rounded iron edge powerfully controlled by a screw was lowered gradually onto the bone midway between the lower two edges, when by forcibly lowering the upper edge the bone was broken, the amount of pressure required being meanwhile indicated on the

scale beam. The same machine was used to test the breaking down strength of the pasterns, the rear leg of the hog from the hock down was placed in a natural upright position in the machine and by bringing pressure upon it the amount required to break down the pastern joint was determined. The results of these tests are given in tables Nos. IV and V, where the actual average breaking strength of the two thigh bones and the pasterns of each pig on the experiment are given. From these results it will be seen that while the actual average breaking strength of the thigh bones in lot 1, fed corn and rye, was greater than the average breaking strength of the thigh bones in lot 2, fed peas and shorts, the proportional breaking strength to 100 pounds of dressed weight is 12.7 per cent. greater in the lot fed peas and shorts. A like result will be noticed in the comparison of the averages of breaking down strength of the pasterns of the two lots except that the proportionate strength of the lot fed peas and shorts is greater in breaking down strength of pasterns than in the thigh bones, in this case it being 15.7 greater than in the lot fed corn and rye.

TABLE No. VI.— *Table comparing the different breeds.*

Record number.	Breed.	Amount of grain eaten per day.	Daily gain of each pig.	Total gain of each pig.	Amount of feed for 100 lbs grain.	Cost of 100 lbs gain.	Intestinal fat.	Thickness of surface fat.
		Lbs.	Lbs	Lbs.	Lbs.		Lbs.	In.
162	Poland-China	6.128	1.093	92	559	$5.037	6.158	1.27
163	Poland-China	5.354	619	52	865	8.908	7.57	1.247
	Average	5.741	.857	72	712	$6.972	6.864	1.258
131	Berkshire	5 45	1.	84	515	$4.946	6.399	1.168
137	Berkshire	4.562	.809	68	593	5.805	5.033	.974
	Average	5.006	.905	76	554	$5.375	5 371	1.081
	Yorkshire	4.604	.809	68	568	$5.118	5.431	1.05
111	Yorkshire	3.794	.589	33	644	6.6 2	....	....
	Average	4.199	.699	50.5	606	$5.875	5 431	1.05
114	Razor-back Poland-China	4.529	.714	60	596	$5.37	6.34	1.212
10[illegible]	Razor-back Poland-China	6.126	1.19	100	514	4 631	5.909	1 238
116	Razor-back Poland-China	5 551	.583	49	952	9.801	8 664	1.096
113	Razor-back Poland-China	4.139	.476	40	869	8 952	6.917	1.128
	Average	5 086	.741	62.3	733	$7.188	6.98	1.168

Grouping the results as shown in table No. 6 we have a comparison of the results of the feeding qualities and the slaughter test of each breed of hogs represented on the experiment. In justice to the Yorkshires it must be said that pig No. 111 of this breed did not thrive well during the latter part of the experiment, the data concerning it being omitted from the results after observing that it was not eating or gaining as well as others on the experiment.

II. The Results of a Feeding Trial to Determine the Comparative Effect of Feeding Pigs Rations of Corn Meal and of Ground Peas.

W. L. CARLYLE.

The experiment here reported is a duplicate in many respects of the one which preceded it, the results of which have been given in the foregoing pages. Our purpose is to carry on a series of these feeding trials with pigs for a term of years, the object being to compare the effect of feeding the various farm grains on the growth, nature and development of the carcass and the internal organs of pigs, and incidentally gather as much information as possible concerning the money value of these different kinds of grains for pork production.

The purpose in reporting these experiments from time to time in the Annual Report of the Station is to call attention to the various facts as the work progresses without drawing any definite conclusions until sufficient data have been accumulated to warrant them. Very much credit is due the herdsman, Geo. D. Little, for the careful and painstaking manner in which he has co-operated with us in carrying on the experiments.

PLAN OF EXPERIMENT.

It was deemed best to confine the rations fed each lot to a single kind of grain since deductions as to the value and effect of each grain fed would be much more positive under these conditions than where two or more kinds were fed in combination.

Eventually it may be best to compare the effect of feeding various combinations of grains as it would be reasonable to expect that no one kind would give as good results as would a combination of several, especially as the animals chosen for the work are young, growing pigs.

In selecting the pigs for this experiment four fall litters were available. These were a litter of Yorkshires, one of Razor-backs and one each of cross-bred Razor-back Berkshire and Cross-bred Razor-back Poland-China pigs. The animals selected were all thrifty and had all received the same kind of feed and the same care from birth until the beginning of the experiment. The pens, feeding-stalls and other conditions of the experiment were the same as described in the experiment preceding this. Ten pigs were selected and divided into two lots as nearly equal in every way as possible, care being taken to have all the litters represented by the same number of pigs in each lot. The accompanying table, No. I, gives full details of data concerning pigs and their breeding at the beginning of the experiment.

TABLE I.—*Data concerning pigs at the beginning of the experiment January 5, 1901.*

LOT I.—PEAS.						LOT II.—CORN.					
Record Number.	Breed.	Number of dam.	Sex.	Age, days.	Weight, lbs.	Record number.	Breed.	Number of dam	Sex.	Age, days.	Weight,
238	Razor-back Berkshire.....	64	Barrow.	99	42.	229	Razor-back ...	1	Sow	127	42.5
247	Yorkshire	88	Sow.....	106	38.	228	Razor-back ..	1	Sow	127	50.
224	Razor-back....	1	Sow. ..	127	46.5	248	Yorkshire.....	88	Barrow.	106	43.
222	Razor-back Poland-China	17	Barrow.	129	63.	218	Razor-back Poland-China	17	Barrow.	129	61.
225	Razor-back ...	1	Sow.....	127	51.	241	Razor-back Berkshire....	64	Sow	99	39.

The Razor-backs were bred from a pair of pigs captured running wild in Indian Territory, and procured by the station for the purpose of investigating the powers of digestion, strength of bone, development of internal organs, vitality and ability to ward off disease of these native hogs, compared with the improved breeds of swine kept at the Station. They were chosen

for this experiment for the reason that it offered an opportunity to compare these animals with other pigs of the same age, possessing varying amounts of the blood of the improved breeds.

RESULTS OF THE EXPERIMENT.

A study of table No. I reveals a vast amount of interesting data concerning the feeding and gains made by the individual pigs on the experiment. It is not our purpose to elaborate comparisons of the feeding powers of the different pigs at this time, the data being published for the reason that it has a bearing on the results of the primary object of the experiment, which is a comparison of the effect of the two kinds of grain fed upon the carcasses of the pigs, and for the further reason that it preserves the data in our report in such a condition that it may be readily drawn upon and referred to in future work with these Razor-back pigs and their crosses. It will be seen from this table that the two Yorkshires and the cross-bred Razor-back Poland-China pigs were taken from the feeding experiment and slaughtered six weeks earlier than the Razor-backs and the cross-bred Razor-back Berkshires. This was done for the reason that it was considered important to have the animals as nearly as possible of the same live weight and the same stage of maturity when they were slaughtered so that more accurate comparisons could be made of the development of the internal organs, strength of bone, etc., of all the pigs on the experiment.

Attention is called to the varying amounts of feed eaten by the individual pigs of both lots in the different two-week periods and the resultant gains. No good and sufficient reason can be assigned for the apparent stagnation in growth to which all of the pigs were subject from time to time. The two Yorkshire pigs, the cross-bred Razor-back Poland-China No. 218 and the Razor-back No. 224 made the most constant gains throughout the experiment and of these the Yorkshire No. 248 and the cross-bred No. 218 were the most constant, and it will be noticed further on that they made remarkably cheap gains. The pigs in lot I as a whole ate 3,239 pounds of peas and gained 715 pounds in live weight during the experiment, while lot II with the same number of pigs and for the same length of time consumed 2,984

TABLE II.— *Showing amount of feed eaten, initial and final weights, the gain of the individuals in two week periods, and the total weights of feed and of gain.*

	Lot I.— Peas.											
	238		217		224		222		225		Lot I.	
	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Total Feed.	Total wt. and gain
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning	....	42	......	38	.....	46.5	......	63	......	51	....	240.5
1st two weeks	20.5	5	20.5	3	28.5	9.5	30.25	2	28.5	3	123.25	22.5
2d two weeks	15.0	—10	22.25	4	27.0	3	36.25	8	26.0	6	126.5	11
3d two weeks	24.25	4	34.5	12	33.75	12	40.00	16	34.25	10	166.75	51
4th two weeks	29.95	16	36.0	8	30.1	10	52.0	14	30.1	8	178.15	56
5th two weeks	27.7	9	38.6	10	38.8	8	51.5	9	38.8	10	205.4	46
6th two weeks	41.2	13	50.9	18	41.2	16	76.3	19	41.2	15	250.8	81
7th two weeks	48.8	11	51.7	10	50.1	8	74.0	18	48.8	7	273.4	54
8th two weeks	41.3	— 3	54.8	12	54.8	10	74.0	1	51.8	13	279.7	33
9th two weeks	50.7	27	58.5	20	41.0	10	57.0	22	47.1	8	251.3	87
10th two weeks	55.6	10	66.0	17	58.5	12	53.6	16	58.5	12	292.2	67
11th two weeks	61.2	16	73.6	20	57.8	12	61.2	21	73.6	14	327.4	83
12th two weeks	63.9	16	75.0	17	55.4	12	75.0	10	63.9	15	333.2	70
13th two weeks	54.1	8	......	...	46.8	6	......	...	52.6	11	153.5	25
14th two weeks	52.3	— 2	......	...	52.3	6	......	....	52.3	5	156.9	9
15th two weeks	37.8	9	......	..	37.8	5	......	....	37.8	3	113.4	17
Total feed and gain.	631.3	129	582.35	151	653.85	139.5	681.1	156	688.25	140	3,239.85	715.5
Total weight.	......	171	......	189	......	186	......	219	......	191	....	956

	Lot II.— Corn.											
	229		228		248		218		241		Lot II.	
	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Feed.	Gain.	Total Feed.	Total wt. and gain.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight at beginning	......	42.5	......	50	.....	43	......	61	......	59	....	235.5
1st two weeks	30.95	4.5	30.95	6	22.3	3	30.95	6	22.55	4	137.7	23.5
2d two weeks	34.5	7	34.5	3	26.0	8	35.5	8	26.0	4	156.5	30
3d two weeks	31.75	3	31.75	2	33.0	7	45.75	15	31.0	5	173.25	32
4th two weeks	26.85	8	26.45	4	39.0	14	49.95	12	26.45	8	168.7	46
5th two weeks	29.6	......	24.9	— 1	41.8	7	36.7	13	26.1	—1	179.1	18
6th two weeks	31.5	7	22.8	7	55.8	13	72.6	20	27.7	9	210.4	56
7th two weeks	35.0	8	26.0	2	47.6	11	72.0	16	36.0	8	216.6	45
8th two weeks	40.4	7	33.2	7	45.7	11	72.0	14	43.8	10	235.1	49
9th two weeks	41.5	22	39.8	10	62.6	22	79.0	22	49.4	16	272.3	92
10th two weeks	41.0	— 1	31.5	2	66.5	14	80	19	53.3	7	272.3	41
11th two weeks	45.6	14	31.4	6	81.2	24	81.2	22	49.4	12	288.8	77
12th two weeks	44.0	5	24.9	3	79.0	11	79.0	9	46.2	6	273.1	34
13th two weeks	38.0	11	21.7	5	.....	....	......	...	42.9	11	102.6	27
14th two weeks	45.4	8	22.6	1	.....	....	......	...	46.1	8	114.1	17
15th two weeks	36.8	1	18.3	— 2	.....	....	......	...	38.8	2	93.9	1
Total feed and gain.	532.85	104.5	420.75	51	600.5	145	754.65	176	565.7	109	2,894.45	588.5
Total weight.	......	147	.....	101	.....	188	......	237	......	148	....	824

pounds of corn and gained 588 pounds in live weight. The pigs in lot I therefore ate 345 pounds more grain than did those in lot II and gained 127 pounds more in live weight. These results would seem to indicate that pigs fed peas, while not eating so heavily of their feed in the beginning of this experiment as did their brothers fed on the corn ration, yet ate considerably more towards the close of the experiment, which would seem to indicate that peas are a more palatable and complete food than corn when fed to pigs for a period of from ten to twenty-five weeks.

TABLE NO. III.— *Summary of feed eaten and gain made by pigs.*

	Lot I, peas.	Lot II, corn.
	Lbs.	Lbs.
Average amount of grain eaten per pig per day	3.36	3.07
Average gain of each pig per day	.75	.63
Average amount of feed for 100 lbs. gain	452	491
Average cost of feed for 100 lbs. gain	$6.78	$4.34
Amount of digestible protein in 100 lbs. of feed	16.8	7 9
Amount of digestible carbohydrates in 100 lbs. of feed	51.8	66.7
Amount of digestibie fat in 100 lbs of feed	.7	4.3
Amount of digestible protein for 100 lbs. gain	75.936	38.789
Amount of digestible carbohydrates for 100 lbs. gain	234.136	327.497
Amount of digestible fat for 100 lbs. gain	3.164	21.113
Nutritive ratio	1:3.18	1:9.75

Table No. III gives a summary of feed eaten and gains made by the pigs together with much data concerning the feed of the two lots. From this it will be seen that the pigs fed on peas ate 3.36 lbs. per head daily and gained .75 of a pound in live weight, while the pigs fed corn ate 3.07 lbs. per head daily and gained .63 of a pound. In this experiment therefore it required 4.52 lbs. of peas to produce one pound of live weight gain on a lot of growing pigs of mixed breeding, while it required 4.91 lbs. of corn to produce one pound of live weight gain on the same kind of pigs. It is evident therefore that pound for pound

peas are more valuable for pork production than corn but when the market price and the cost of production of the two kinds of grain are considered corn is evidently much the cheaper feed. The prices adopted for the two kinds of grain used were ninety cents per bushel for peas and forty-five for corn, the prevailing market prices for these grains in Wisconsin. While marketable peas for table purposes may never be low enough in price to render them very profitable as a feed for hogs in Wisconsin, yet in those districts where peas are grown extensively there is frequently large quantities that are not suitable for table use. Under such conditions it would seem that they might be utilized very advantageously in feeding hogs inasmuch as we shall see later that the quality of the pork from hogs fed peas is particularly fine on account of the large proportion of lean meat produced.

In discussing another experiment in this report, page 32, attention is called to the nutritive ratios of the two rations fed. In that experiment the ration containing a much larger proportion of carbhydrates to protein, than is called for in any of the feeding standards given by investigators on this phase of the feeding subject, gave much better results than the other ration fed in comparison. The latter contained a much smaller proportion of carbhydrates to protein than the standards demanded. In fact the nutritive ratio in one ration was just double what it was in the other.

In the experiment now under consideration it will be seen that the nutritive ratio of the corn ration was over three times as wide as was the ratio in the ration of peas fed and yet the lot of pigs fed peas gave much better results than the lot fed corn. These results, when viewed from the standpoint of the chemical analyses of the foods, are, to say the least, very contradictory and surprising. It is evident that a great amount of carefully collected data must be forthcoming on this phase of the feeding problem before any definite conclusions can be drawn. It would seem from the results of these two experiments that the protein and carbhydrates in shorts and rye have a different feeding value for pigs than the same substances in peas and corn. Accepting the German feeding standards as

correct, the rations made up of corn and rye and peas and shorts should have given better results than those composed entirely of corn and of peas, yet the opposite is the case, the latter rations giving the best result in both instances.

FINDINGS OF THE SLAUGHTER TESTS.

A comparison of the results of the slaughter tests, which gives the amount of blood, weight of the various internal organs, capacity of the stomach, etc., of the pigs in the two lots, confirms the observations made in the previous experiment, the comparisons being rendered much more striking by confining the rations fed to peas alone in lot I and to corn alone in lot II. Owing to the fact that an equal number of the pigs from each lot were matured to the stage at which we wished to slaughter them some weeks earlier than the others, it was decided to proceed with the slaughter tests with those that were mature, leaving the others to continue on the feeding experiment until they reached the degree of maturity desired. This was considered important since better comparisons could be made in every case with pigs approximating the same weight. At the same time the lessened period of feeding before maturity in the case of some of the pigs would tend to reduce the cost of 100 lgs. gain, while of the other pigs that were fed for a longer period it would tend to increase this cost.

From the data secured in the slaughter tests, as given in tables Nos. IV and V, it will be seen that there was a very marked increase in the development of the internal organs of the pigs fed peas as compared with those fed corn, this development extending throughout the entire carcass, the only exception being in the comparative thickness of the outside fat. The accompanying photos of the carcasses of the two lots are presented for comparison showing the proportion of lean and fat meat in the various parts of the carcass.

Attention is called especially to the greater devlopment of the stomach and intestines of the lot fed peas. The average capacity of the stomachs of this lot of pigs as determined by emptying them of their natural contents and estimating the capacity of each by the number of pounds of water they would contain was

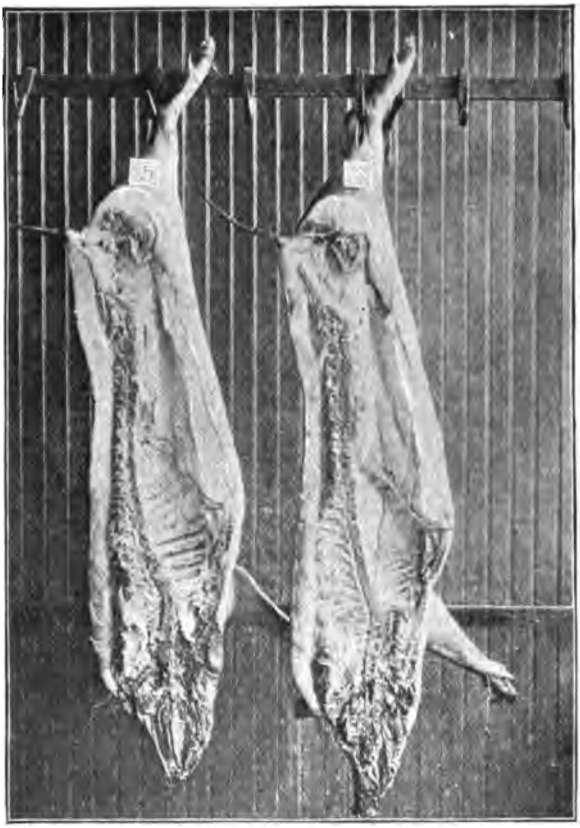

FIG. 14.—Showing carcasses of a pair of Razor-back Berkshire pigs; No. 5 fed corn, No. 6 peas. Note the greater length of body in the pigs fed peas, also the great difference in the proportion of lean meat to fat, as shown in the cross-section.

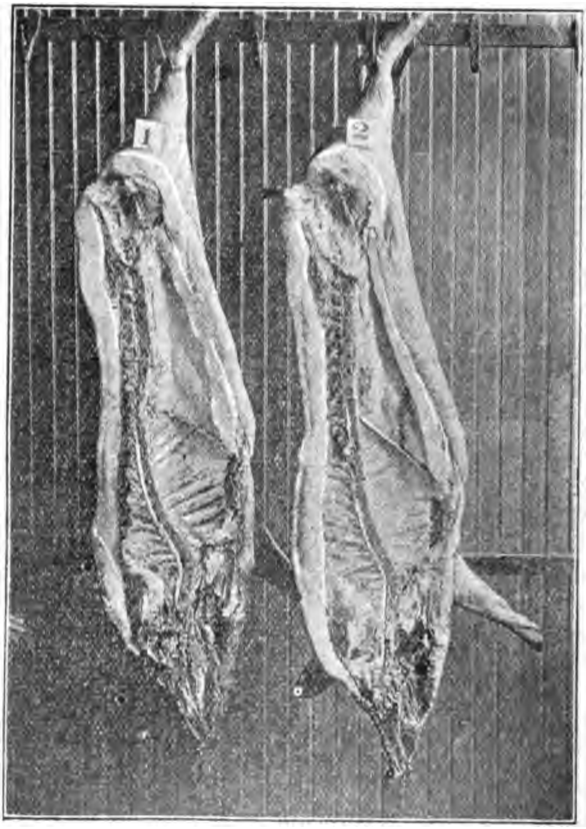

FIG. 15.—Showing carcasses of a pair of Razor-back pigs. No. 1 fed corn, and No. 2 fed peas. Note that the positions of the cross sections have been reversed in photographing. The corn-fed section appears on the right.

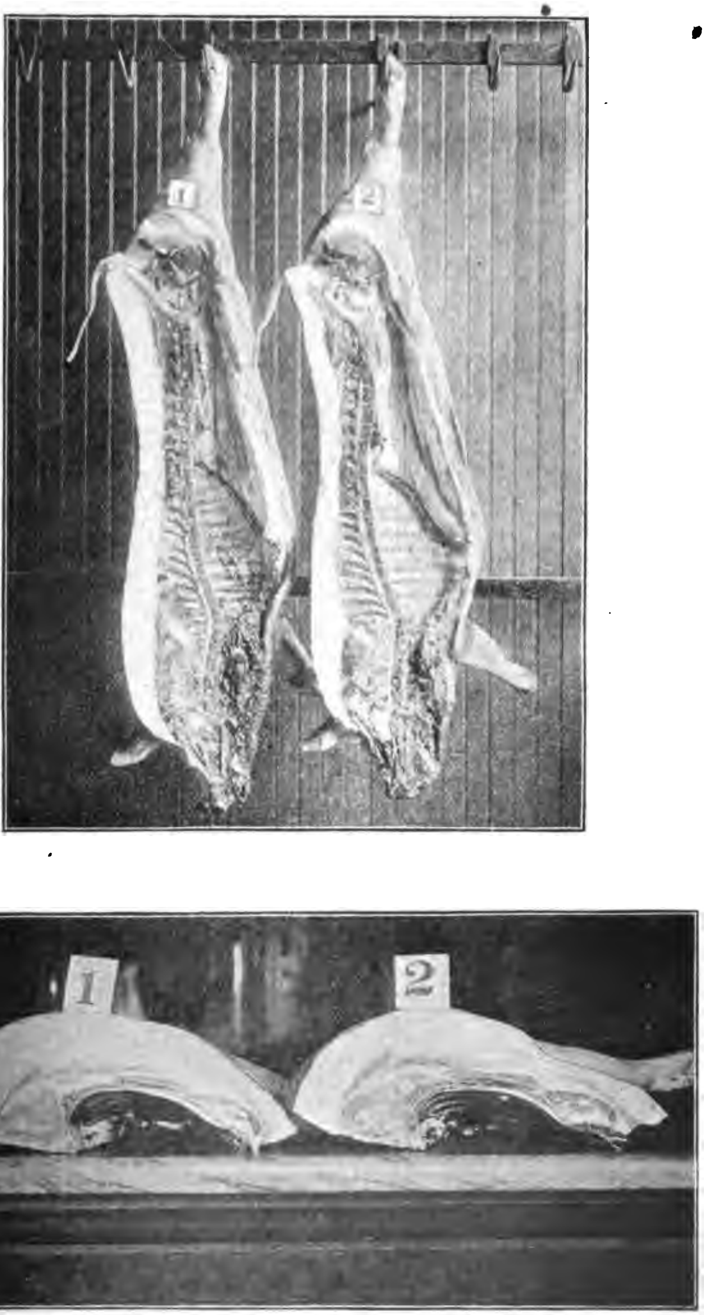

FIG. 16.—Showing carcasses of a pair of Yorkshire pigs, No. 1 fed corn, No. 2 fed peas.

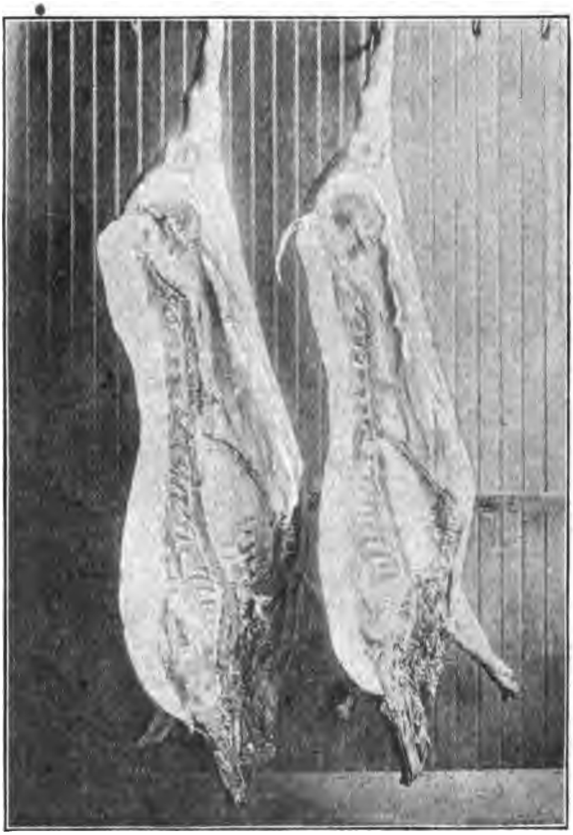

FIG. 17.—Showing carcasses of a pair of Razor-back Poland-China pigs, No. 3 fed corn, No. 4 fed peas. Note the small proportion of lean to fat in bulk of these carcasses, especially in one fed corn.

TABLE IV.—*Weight of carcass and various organs of pigs fed a ration of peas in opposition to a ration of corn.*

LOT I.—Peas.

Record number.	Breed.	Live weight.	Dressed weight.	Weight of blood.	Weight of intestines.	Weight of spleen.	Weight of liver.	Weight of heart.	Capacity of stomach.	Intestinal fat.	Kidney fat.	Length of small intestine.	Length of large intestine.	Length of body.	Weight of kidneys.	Thickness of fat on loin.	Thickness of fat on back.	Thickness of fat on shoulder.	Breaking str'ngth of thigh bones.	Breaking-down strength of hind pasterns.
		Lbs.	Lbs.	Lbs.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Lbs.	Lbs.	In.	In.	In.	Oz.	In.	In	In.	Lbs.	Lbs.
238	Razor-back Berkshire	171	130	4.4	13.7	4.0	2.2	8.0	9.2	3.1	7.125	688	180	37.5	8.0	1.5	1.625	2.0	642	375
247	Yorkshire	188	144	5.8	15.8	3.2	3.2	6.4	8.3	1.9	8.25	600	222	36.0	6.0	1.375	1.875	2.75	791	370
224	Razor-back	186	142	5.2	13.7	3.2	2.9	6.4	7.9	3.7	7.187	636	180	39.5	10.0	1.875	2.000	1.375	793	360
222	Razor-back Poland China	218	167.5	6.8	18.2	2.4	3.5	6.4	9.7	3.5	9.25	636	192	39.0	14.0	2.000	2.000	3.000	1230	343
225	Razor-back	191	151	6.1	13.0	4.8	2.4	6.4	10.1	4.7	9.593	666	174	39.5	10.0	2.250	2.375	2.750	823	340
	Average	**190.8**	**146.9**	**5.66**	**14.88**	**3.52**	**2.84**	**6.72**	**9.04**	**3.8**	**8.281**	**649.2**	**189.6**	**38.3**	**9.6**	**1.8**	**1.975**	**2.175**	**861.8**	**357.6**
	LOT II.—Corn.																			
229	Razor-back	150	120	4.0	9.8	4.0	2.1	6.4	7.8	3.0	7.187	535	144	38.5	6.0	2.000	2.125	3.000	456	234
228	Razor-back	104	81	3.4	7.5	4.0	1.4	4.8	7.1	3.2	2.937	528	150	34.5	5.5	1.125	1.25	1.750	610	170
248	Yorkshire	192	147	4.9	13.4	1.6	2.3	4.8	9.9	1.2	8.000	640	198	37.0	7.0	2.125	2.125	3.000	720	248
218	Razor-back Poland China	241	193	5.6	15.5	3.2	2.8	8.00	9.1	4.7	9.250	660	192	42.5	14.0	3.00	2.75	3.50	1.027	273
241	Razor-back Berkshire	148	117	3.7	10.4	3.2	2.2	6.4	9.7	2.7	6.125	522	174	34.5	5.5	1.75	2.000	2.500	583	219
	Average	**167**	**131.6**	**4.32**	**11.32**	**3.2**	**2.16**	**6.08**	**8.72**	**2.96**	**6.7**	**577.2**	**171.6**	**37.4**	**7.6**	**2.00**	**2.05**	**2.55**	**679.2**	**2.42**

found to be 9.04 lbs., while the average capacity of the stomachs of the pigs fed corn was 8.72 lbs. The average length of the small intestines of the lot fed peas was 649.2 inches, as against an average length in the lot fed corn of 577.2 inches. From these facts we would expect the lot fed peas to have better digestive and assimulative powers. It is noteworthy that, during the progress of the experiment, the pigs fed peas drank much more water than did those fed corn.

Attention is also called to the marked difference in the strength of bones and of tendons in the two lots. The average breaking strength of the thigh bones in the lot fed peas being 861.8 lbs., as compared with 679.2 lbs. in the lot fed corn, this difference being maintained, though in a lessened degree, when figured from the standpoint of 100 lbs. dressed weight of carcass, as seen in table No. V.

TABLE No. V.—*Amount of blood, spleen, liver, heart, kidneys, etc., for each 100 lbs. dressed weight of hog.*

LOT I.—Peas.

Record number.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kidneys.	Thickness of outside fat.	Kidney fat.	Intestinal fat.	Per cent. dressed.	Thigh bone strength for each 100 lbs. weight.	Postern strength for each 100 lbs. weight.
		Lbs.	Oz.	Lbs.	Oz.	Oz.	In.	Lbs.	Lbs.		Lbs.	Lbs.
236	Razor-back Berkshire......	3.384	3.077	1.692	6.154	6.154	1.314	5.481	2.385	76	493	288
247	Yorkshire........	4.028	2.222	2.222	4.444	4.167	1.389	5.729	1.319	76.5	549	256
224	Razor-back	3.662	2.253	2.042	4.507	7.042	1.467	5.061	2.605	76.3	558	253
222	Razor-back Poland-China ..	4.060	1.433	2.089	3.821	8.358	2.089	5.522	2.089	76.8	752	204
225	Razor-back	4.039	3.179	1.589	4.238	6.622	1.618	6.353	3.112	79	545	225
	Average	3.834	2.433	1.927	4.633	6.468	1.575	5.629	2.302	76.9	579.4	245.2

LOT II.—Corn.

Record number.	Breed.	Blood.	Spleen.	Liver.	Heart.	Kidneys.	Thickness of outside fat.	Kidney fat.	Intestinal fat.	Per cent. dressed.	Thigh bone strength for each 100 lbs. weight.	Postern strength for each 100 lbs. weight.
229	Razor-back	3.333	3 333	1.750	5.333	5.000	1.979	5.989	2.500	80	380	195
228	Razor-back	4.197	4.938	1.728	5.925	6.790	1.697	3.626	3.951	77 8	753	209
248	Yorkshire........	3.333	1.088	1.564	3.265	4.762	1 643	5.442	.816	76.5	489	169
218	Razor-back Poland-China ..	2.901	1.658	1.451	4.145	7.254	1.203	4.792	2.435	80	532	141
241	Razor-back Berkshire.......	3.162	2.735	1.880	5.470	4.701	1.780	5.235	2.308	79	498	187
	Average.......	3.385	2.75	1.674	4.827	5.701	1.661	5.017	2.402	78.6	530.4	180.2

A comparison of the different breeds and crosses represented in this experiment is given in table No. VI. The Razor-back Poland-China cross-bred pigs ate the most grain, made the greatest average gain, had much the larger quantity of internal fat, and the greatest thickness of surface fat on outside of body. The Yorkshires were ahead in requiring the least amount of food per 100 lbs. gain. The Razor-back pigs ate the least grain, made the smallest gains, and required the greatest amount of feed for 100 lbs. gain, while at the same time they had the second largest quantity of internal fat. The cross-bred Razor-back Berkshire pigs stand third on the list in amount of feed eaten and gains made. They also come third in thickness of external fat and show the least amount of internal fat. The accompanying cuts reproduced from photographs show very clearly the characteristics of each breed as shown by the carcasses. It is necessary to add here that the Yorkshires represented on this experiment were not the Improved Large Yorkshire but the smaller type of this breed.

TABLE VI.— *Comparing amount of feed eaten, rate of gain, cost of gain, and strength of bones and tendons of each pig with average of each breed represented.*

Record number.	Breed.	Av. amount of grain eaten per day.	Av. daily gain of each pig.	Total gain of each pig.	Amount of feed for 100 lbs. gain.	Cost of 100 lbs. gain.	Amount of internal fat.	Thickness of surface fat.	Av. breaking strength of thigh bones.	Av. breaking down strength of hind postern.
		Lbs.	Lbs.	Lbs.	Lbs.		Lbs.	In.	Lbs.	Lbs.
222	Razor-back Poland-China...	4.05	.92	156.0	437.0	$6.549	12.75	2.33	1,260	343
218	Razor-back Poland-China...	4.49	1.05	176.0	429.0	3.445	13.95	3.08	1,027	273
	Average.......	**4.27**	**.985**	**166.0**	**433.0**	**$4.997**	**13.35**	**2.705**	**1,143**	**308**
238	Razor-back Berkshire.......	3.02	.62	129.0	491.0	$7.375	10.225	2.56	642	375
241	Razor-back Berkshire.......	2.69	.52	109.0	519.0	4.168	8.825	2.08	583	219
	Average.......	**2.86**	**.57**	**119.0**	**505.0**	**$5.772**	**9.52**	**2.32**	**612**	**297**
219	Yorkshire........	3.47	.89	151.0	386.0	$5.789	10.15	2.00	791	370
247	Yorkshire........	3.57	.86	145.0	414.0	3.324	9.2	2.42	720	248
	Average.......	**3.52**	**.875**	**148.0**	**400.0**	**$4.556**	**9.67**	**2.21**	**755**	**309**
224	Razor-back......	3.11	.66	139.5	469.0	$7.03	10.887	1.75	793	360
225	Razor-back......	3.18	.67	140.0	491.0	7.374	14.3	2.46	823	340
228	Razor-back......	2.00	.26	51.0	779.0	6.256	6.14	1.38	610	170
229	Razor-back.......	2.63	.50	104.5	529.0	4.248	10.187	2.38	456	234
	Average... ..	**2.73**	**.52**	**109.5**	**547.0**	**$6.227**	**10.378**	**1.99**	**670**	**276**

SUMMARY OF RESULTS OF THESE EXPERIMENTS.

The results of the two experiments reported in preceding papers would seem to warrant the following conclusions:

1. That feeds given growing pigs exercise a marked influence on the proportion of fat to lean meat in the carcass; also may materially affect the development of the various internal organs and the breaking strength of the bones and tendons.

2. That a ration of peas and shorts give a larger proportion of lean meat, firmer flesh, stronger bone and more blood in a group of growing pigs than a ration of corn and rye.

3. That a ration of peas, when compared with a ration of corn, gave more marked results in these respects than did the ration of peas and shorts when compared with corn and rye.

4. That rations of corn and corn and rye when fed to growing pigs tended to retard the development of their internal organs and to increase the proportion of fat meat.

5. That the thigh bones of pigs fed upon peas were on the average 26.9 per cent. stronger than the thigh bones of pigs of the same age and breeding fed upon corn.

6. That at the prevailing market prices for the grains in the rations fed, corn has proved to be a much cheaper feed for hogs than peas. Owing to the observed tendency to a lessened development of the internal organs and a reduction in the comparative strength of bones in corn fed hogs it is still an open question if, in the case of breeding stock, it would not be advisable to feed a much more expensive ration than corn and build up thereby a stronger vitality in the animal.

III. The Feeding Value of Rape for Swine.

W. L. CARLYLE.

In the 14th Annual Report of this station, published in 1897, J. A. Craig reported the results of two feeding trials with pigs, the object of the experiments being to determine the feeding value of rape for swine.

The first trial was begun with twenty pigs about eight months old. They were divided into two lots of ten each, lot I to have rape pasture in connection with grain feed composed of two parts corn and one part shorts; and lot II to receive the grain only. The plan was to keep both lots of equal weight as it was thought that this was the best way of arriving at the feeding value of the rape plant. The experiment was completed in seventy-six days. A summary of the results are given in the accompanying table, from which it will be seen that lot I ate the rape from almost one-third of an acre and required 710 lbs. less of corn and 352 lbs. less of shorts than lot II receiving no rape.

TABLE No. 1.—*First trial.*

	Corn.	Shorts.	Rape.	Gain.
	Lbs.	Lbs.	Acre.	Lbs.
Lot I, rape	1,386	690	.32	853
Lot II, penned	2,096	1,042	....	857
Difference in favor of Lot I	710	352	....	....

The gains made in the two lots were about equal in both cases. The area of rape eaten was therefore equivalent to 1,062 lbs. of grain, or one acre of rape pastured under these conditions would result in a saving of 3,318 lbs of grain.

SECOND FEEDING TRIAL.

The second feeding trial, also reported in the 14th Annual Report, was conducted in 1896. In this 38 pigs were used, the plan of the experiment being the same as in the first trial. The

accompanying table gives the results. This trial was not so favorable for the rape, but it will be seen that the feeding of a little over one-half acre of rape resulted in a saving of 886.2 lbs. of corn and 444 lbs. of shorts, a total of 1,330.2 lbs. of grain. An acre of rape in this case, therefore, was equal to 2,217 lbs of grain.

TABLE No. 2.—*Second trial.*

	Corn.	Shorts.	Rape.	Gain.
	Lbs.	Lbs.	Acre.	Lbs.
Lot I, rape	2,220.3	1,109	.6	1,066
Lot II, penned	3,106.5	1,553	....	1,076
Difference in favor of Lot I	886.2	444	....	....

THIRD FEEDING TRIAL.

The third feeding trial was reported by the writer in the 15th Annual Report of the Station. The object of this trial was to test the comparative value of rape vs. clover pasture for young growing pigs. Forty pigs were selected for this experiment and were divided into two lots as nearly equal in every way as possible. The pigs were between five and six months old at the beginning of the experiment. The grain feed given was the same in character and amount to both lots and consisted of two-thirds cornmeal and one-third shorts. The pigs in lot I were pastured on a small area of rape by means of a movable fence, a fresh portion being given them as they required it. The pigs in lot II had the run of a ten-acre field of second growth clover, one-half of the field having been mowed in August. The pigs were given the same care and management in all particulars and with results as shown in the accompanying table.

TABLE NO. 3.—*Summary of results of rape versus clover experiment, 1898.*

	Lot I, Rape.	Lot II, Clover.
	Lbs.	Lbs.
Initial weight of pigs	2,111.	2,091.
Final weight of pigs	3,154.	3,032.1
Grain eaten, ⅓ shorts, ⅔ cornmeal	4,083.75	4,083.75
Total gain made	1,043.	941.
Amount of grain for 100 lbs. gain	391.	439.
Average gain of each pig during experiment	54.89	49.52
Average daily gain per pig	.87	.78
Average daily gain in last three weeks	17.76	10.38

The results of this trial indicated that rape was to be preferred to clover as a pasture for growing pigs since the average increased gain of the 19 pigs on rape over the 19 on clover was five and one-third lbs. for each pig in a period of nine weeks, or a trifle over one-half lb. per pig per week.

In the table giving a summary of the results of this experiment, it will be noticed that it required 439 lbs. of grain to produce 100 lbs. of live weight gain in the lot of pigs on the clover pasture, while it required but 391 lbs. to produce 100 lbs. of gain in the lot fed rape. A difference of 48 lbs. of feed saved for every 100 lbs. of gain in favor of the lot fed rape.

TABLE NO. 4.—*Summary of results of rape versus clover experiment, 1899.*

NO. OF LOT.	Lot I, Rape.	Lot II, Clover.
	Lbs.	Lbs.
Initial weight of pigs	2,139.	2,138.
Final weight of pigs	3,621.	3,573.
Grain eaten, ⅓ shorts, ⅔ cornmeal	4,965.	4,965.
Total gain made	1,492.	1,435
Amount of grain for 100 lbs. gain	332.	346.
Average gain of each pig during experiment	71.05	68.33
Average daily gain per pig	1.27	1.22
Average daily gain in first four weeks	28.21	25.07
Average daily gain in last four weeks	25.07	26.18

FOURTH FEEDING TRIAL.

The fourth feeding trial was conducted by the writer and reported in the sixteenth annual report. This trial was very similar in every way to the one which preceded it. Forty-two pigs were selected, 21 in each of two lots. The clover and rape on which the pigs were fed in this trial was much the same as in the preceding. The grain consisted of one-third shorts and two-thirds corn meal.

The accompanying table gives a summary of the results of this trial. From this it will be seen that the 21 pigs on rape gained 37 lbs. more in eight weeks than did the same number of pigs pasturing on clover, both eating the same amount of grain meanwhile. The gains made by all the pigs in this trial were very satisfactory, the average daily gain per pig of the lot on rape being 1.27 lbs. and of the lot on clover 1.22 lbs. During the eight weeks of this trial the pigs in lot I ate the rape from approximately three-fourths of an acre of land. While this experiment did not give results so much in favor of the rape over the clover as did the preceding one, yet it will be seen that each pig on the rape gained an average of 2.7 lbs. more than the average of the lot on clover, during the eight weeks of the trial. It will also be seen that the lot on rape required 332 lbs. of the grain mixture to produce 100 lbs. of live weight gain, while the lot on clover pasture required 346 lbs. of grain to produce the same amount of live weight gain, leaving a difference in favor of the rape lot of 14 lbs. of grain per 100 lbs. live weight gain.

FIFTH FEEDING TRIAL.

A short feeding trial of rape alone for growing pigs, averaging in age about 6½ months, was reported by the writer in the 17th annual report. The experiment was conducted somewhat late in the fall when much of the rape was quite mature and woody, though some of it, being of second and third growth, was green and succulent. Thirty-six pigs that were being prepared for a winter feeding trial of exclusive grain feeding were used in this experiment. The field of rape consisted of be-

tween three and four acres, giving the pigs an ample supply of feed at all times. The trial lasted 14 days, during which time the pigs were fed no grain of any kind and they did not care for any water to drink, though it was supplied them on several occasions. At the beginning of the trial the 36 pigs weighed a total of 5,789 pounds, and at its close a total of 5,729 pounds, showing a loss of 60 pounds in live weight for the two weeks of the trial.

The results of this trial would seem to indicate that pigs, as young as those used in this trial, will not eat enough of rape alone to maintain themselves in their live weight. The loss, however, was so comparatively small that it might almost be placed within the limit of variation in weighing, or rather in the amount of food in the pigs' stomachs at the different times of weighing.

SIXTH FEEDING TRIAL.

The results of this experiment are here reported for the first time, the trial having been conducted in the fall of 1900. The object of this experiment being to determine the feeding value of a given area of rape for young growing pigs. The object, therefore, was the same as in the first two trials reported by Craig, but the plan adopted was slightly different. The pigs chosen averaged about four months of age at the beginning of the experiment, being younger than those in the other experiment, and no effort was made to keep both lots the same weight. Each lot of pigs were fed all they would eat readily of a ration of corn meal and shorts, made into a slop with water, immediately before feeding. Thirty-four pigs were chosen from a number of spring litters, and represented the Poland China, Berkshire and Yorkshire breeds, care being taken to have an equal number of each breed in both lots, as well as an equal division in every other way.

The trial began on the 4th day of August, when the rape which was supplied lot II was about 20 inches in height. Lot I was confined in a roomy yard under exactly the same conditions in every way as those surrounding the pigs in lot II, except that they had no green feed of any kind. The pigs in lot II

were confined on a small area of the rape by means of a movable fence which could be changed every few days as the pigs required fresh feed.

TABLE No. 5.—*Showing effect of rape when fed to pigs in connection with a grain ration.*

Lot I. Without rape.	Amount of grain ration.	Weight and Gain in Two-Week Periods of Pigs Without Any Rape.																	Total weight and gain.
		No. 158.	No. 172.	No. 215.	No. 121.	No. 181.	No. 168.	No. 164.	No. 128.	No. 157.	No. 126.	No. 171.	No. 179.	No. 184.	No. 112.	No. 160.	No. 139.	No. 114.	
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Initial weight......	.....	67	49	53	83	56	57	50	76	52	95	56	61	62	51	65	35	49	1017
1st two weeks	650	6	6	8	10	4	8	7	9	10	14	9	4	8	7	8	3	6	127
2d two weeks	840	16	8	15	12	10	12	7	7	7	11	6	13	8	6	12	6	9	165
3d two weeks	854	14	15	11	14	16	11	6	11	8	18	...	13	9	−1	15	7	13	180
4th two weeks	924	14	5	13	16	11	4	9	13	20	17	9	9	11	7	13	*	6	177
5th two weeks	1,108	19	13	20	23	18	18	16	17	3	33	20	15	17	6	24	...	13	265
6th two weeks	1,266	14	17	23	20	19	15	20	23	14	24	18	17	15	7	23	...	11	280
Total feed and gain.	5,642	83	64	90	95	78	68	65	80	62	107	62	71	68	32	95	16	58	1194
Final weight........	.....	150	113	143	178	134	125	115	156	114	202	118	132	130	83	160	51	107	2,211

* Died.

Lot II. With rape.	Amount of grain ration.	Weight and Gain in Two-Week Periods of Pigs Fed Rape with Grain.																	Total weight and gain.
		No. 118	No. 149.	No. 180.	No. 183.	No. 174.	No. 127.	No. 125.	No. 167.	No. 185.	No. 186.	No. 136.	No. 132	No. 170.	No. 216.	No. 178.	No. 147.	No. 182.	
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Initial weight	.....	82	52	66	76	67	80	76	47	46	44	47	64	56	57	45	44	52	1,001
1st two weeks	580	15	8	10	16	11	13	5	4	8	11	6	11	10	8	6	4	6	152
2d two weeks	820	14	4	14	15	12	12	16	9	12	8	8	12	11	14	12	6	9	188
3d two weeks	914	19	8	16	22	18	20	18	13	12	12	8	14	16	14	14	10	15	249
4th two weeks	1,028	12	7	9	13	11	15	14	9	13	7	7	10	15	5	13	6	8	174
5th two weeks	1,218	26	14	30	23	24	24	21	18	19	17	12	14	15	12	12	15	18	304
6th two weeks	1,360	26	...	26	26	24	24	25	18	26	28	14	20	28	13	25	17	4	344
Total feed and gain	5,920	112	41	95	115	100	108	99	71	90	83	55	81	95	66	82	58	60	1,411
Final weight.......	.....	194	93	161	191	167	188	175	118	136	127	102	145	151	123	127	102	112	2,412

Both lots were supplied liberally with coal ashes at all times, which tended greatly to prevent them from rooting the soil.

The tables, presented on another page, give the initial and final weight of each pig, also the gains of each and the total feed, weight, and gain of each lot in two-week periods. One pig from each lot did not thrive well during the trial, and as there was no great difference in their rate of gain before they were removed, the data concerning them is included in the results. Attention is called to the fact, as shown by the figures in the last column of the table, that as the experiment progressed the rate of gain rapidly increased in both the lots, the increased rate from week to week being somewhat greater in the lot fed grain alone.

The summary of the results of this trial, as given in table VI, present some interesting facts. From this summary it will be seen that the lot of pigs on rape not only made a greater gain than the lot on grain alone, but ate more grain in addition to the rape consumed. During the twelve weeks of experiment the 17 pigs in lot I ate 278 pounds more feed than the 17 pigs in lot II, and they gained 217 pounds more in live weight. It will be noticed that it required 420 pounds of feed to produce 100 pounds of gain in the lot fed rape and 437 pounds in the lot fed grain alone. Since it required 4.2 pounds of grain to produce one pound of gain, the increased amount of grain eaten by the rape lot over the other during the experiment would produce 66 of the 217 pounds of increased gain made by this lot, leaving 151 pounds to be credited to the rape eaten. As it required 4.2 pounds grain to produce 1 pound of gain, then it is but reasonable to conclude that it would have required 151x4.2 or 634 pounds as the amount of grain saved by the rape eaten. The area of land from which the rape was eaten was 15,295 square feet, of 5-14 of an acre; consequently one acre of rape in this trial would have resulted in a saving of 1,775 pounds of grain, worth at the market prices of the grains fed $14.20.

TABLE No. 6.—*Summary of results in feeding pigs a grain ration with and without rape.*

No. of Lot.	Lot I, without rape.	Lot II, with rape.
	Lbs.	Lbs.
Weight of pigs at beginning	1,017.	1,001.
Weight of pigs at close	2,211.	2,412.
Grain eaten, ½ shorts, ¼ cornmeal	5,642.	5,920.
Total gain made	1,194.	1,411.
Average gain of each pig	70.2	83.
Average daily gain of each pig	.89	1.06
Average daily gain 1st 6 weeks	0.71	0.88
Average daily gain 2nd 6 weeks	1.08	1.23
Amount of grain feed per 100 lbs. gain	437.0	420.0
Cost of grain feed per 100 lbs. gain	3.78	3.36
Total cost of grain feed	$45.13	$47.36

SUMMARY.

The results of these feeding trials with rape for pigs would seem to warrant the following conclusions:

1. That with pigs from four to ten months old representing the various breeds of swine, an acre of rape, when properly grown, has a feeding value, when combined with a ration of corn and shorts, equivalent to 2,436 pounds of a mixture of these grain feeds and a money value of $19.49 per acre.

2. That rape is a better green feed for growing pigs than good clover pasture, the pigs fed upon the rape having made on the average 100 pounds of gain on 33.5 pounds less grain than was required by the pigs fed upon clover pasture.

3. That pigs are more thrifty, have better appetites and make correspondingly greater gains when supplied with a rape pasture in conjunction with their grain feed than when fed on grain alone.

4. That a plat of Dwarf Essex forage rape when planted in drills 30 inches apart, early in May in Wisconsin, will yield three good crops of pasture forage in a favorable season.

5. That rape is the most satisfactory and cheapest green feed for swine that we have fed.

6. That every feeder of hogs in Wisconsin should plant each spring a small field of rape adjoining his hog yard, and provide himself with a few rods of movable fence, to properly feed the rape to brood sows and young pigs.

7. That rape should be sown for this purpose in drills 30 inches apart to facilitate the stirring of the ground and cultivation after each successive growth has been eaten off.

8. That hogs should not be turned upon a rape pasture until the plants are at least 12 to 14 inches high and that they should be prevented from rooting while in the rape field.

9. That rape is not a satisfactory feed when fed alone, when it is desired to have any live weight gain made in hogs, though it has been found that they will just about maintain themselves without loss of weight on this feed alone.

IV. The Food Requirements of the Pig for Maintenance and Gain.

F. D. TAYLOR.*

The purposes of the experiment was to ascertain, if possible, the amount of food required to maintain the pig at different periods of growth; also the food required to produce a given increase in weight, and incidentally to compare the high-grade pig with the Razor-back.

PLAN OF THE EXPERIMENT.

Four barrows were chosen. Two were high-grade Berkshires from the same litter; the other two were the result of a cross between an Indian–Territory Razor-back boar and a purebred Berkshire sow. The average weight of the pigs at the begin-

*Thesis submitted for the degree of Bachelor of Science in Agriculture, University of Wisconsin, 1901. Abstrated by W. A. Henry. A report of work in the same line done by William Dietrich, appears in the 16th annual report of this Station.

ning of the experiment was about 50 pounds. It was proposed to at times so feed the pigs as to maintain them without gain or loss in weight. The feed so required is termed the "maintenance ration." The maintenance ration determined, the feed of the pigs was next increased in order to cause them to gain rapidly until they were advanced to a weight of 100 pounds each, when the maintenance period was repeated and followed by another period of gain.

The pigs were kept together in one pen and were fed in another pen, each pig having his own stall with trough. The feed supplied consisted of a mixture of wheat middlings, corn meal and oil meal in varying proportions, as was required to maintain the proper nutritive ratio. Samples of the different feed stuffs were taken from time to time and analyzed. The fifty-pound pig was given a mixture of foods carrying a nutritive ratio of 1:3.9. During period I the ration consisted of three parts corn meal, six parts middlings and one part oil meal. This had the proper nutritive ratio of 1:3.9 for pigs of this weight, viz., 50 pounds.

The extended tables giving the weights of the pigs from day to day, together with the quantities of feed consumed daily, can not be here given. A summary of the feed requirements during the three maintenance periods is shown in the following table:

Average food of support per pig with four pigs during three maintenance periods.

Period—Standard weight.	Actual average weight of pigs.	FEED AND WATER CONSUMED.			
		Shorts.	Corn meal.	Oil meal.	Water.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1st period, 50 lbs.	52.1	.48	.24	.08	4.
3d period, 100 lbs......	103.5	1.14	.57	.19	6.
5th period, 150 lbs	157	1.2	.6	.2	6.

The able shows that the average fifty-pound pig required .48 pounds of shorts, .24 pounds corn meal and .08 pounds oil meal

for maintenance; at 100 pounds weight the average pig took 1.14 pounds of shorts, .57 pounds of corn meal and .19 pounds of oil meal for maintenance; at 150 pounds weight it required 1.2 pounds of shorts, .6 pound of corn meal, and .2 pound of oil meal for maintenance.

Average nutrients in food of support required to maintain pigs of different weights.

	Total food eaten.	Dry matter.	Crude protein	Ether extract	N.-free extract	Crude fiber.	Ash.
	Lbs.	Lbs.	Lbs.	Lbs	Lbs	Lbs.	Lbs.
First period, 50 lbs.	.8	.72	.133	.043	.462	.053	.027
Per 100 lbs. live weight	1.53	1.38	.255	.083	.856	.101	.052
Third period, 100 lbs.	1.9	1.72	.318	.103	1.10	.127	.064
Per 100 lbs. live weight	1.83	1.66	.307	.099	1.05	.122	.062
Fifth period, 150 lbs	2	1.805	.335	.116	1.15	.134	.068
Per 100 lbs. live weight	1.27	1.21	.213	.074	.74	.085	.013
Average per 100 lbs. live weight.	1.54	1.41	.258	.069	.089	.898	.052

The table shows that the average fifty-pound pig ate .72 pounds of dry matter containing .133 pound of protein and .04 pound of either extract, .462 pound of nitrogen-free extract, etc.

The table shows that the fifty-pound pig consumed less than the hundred-pound pig and the hundred-fifty-pound pig less than either the fifty or one-hundred-pound pig *per hundred pounds live weight.*

The table further shows that in the form of dry matter of shorts, corn meal and oil meal, 1.41 per cent. of the live weight of the anmal is required on the average to maintain him, and this in equivalent of middlings would be about 1.37 per cent. of live weight.

It was found during the several maintenance periods that each of the four pigs, though not weighing exactly the same, were still maintained on the same quantity of feed, no difference being found between the Razor-backs and the grade Berkshires.

THE FOOD OF GAIN.

After each maintenance period the allowance of feed was gradually increased until the pigs were given all they would consume without waste. The following table summarizes the results during the gain periods:

Table showing results of feeding for gain.

	Seventy-five pound pig.	One hundred and twenty-five pound pig.	One hundred and seventy-five pound pig.
1. Dry matter consumed for 100 lbs gain	319.12	421.90	540.60
2. Dry matter consumed per head daily	2.55	3.59	4.08
3. Average daily gain	.80	.85	.92
4. Number of days for 50 lbs. gain	62.5	58.8	54.5
5. Dry matter consumed per day for 100 lbs. live weight	3.4	2.90	3.06
6. Estimated dry matter per day in food of support	1.22	1.76	1.80
7. Food of support in per cent. of live weight	1.62	1.40	1.08
8 Food of support in per cent. of total food consumed	47.80	48.8	40.80
9. Ratio of dry matter in food of support	1.00	1.44	1.48

We note from line 1 that the food required for 100 pounds of gain increased with the increased weight of the pigs. Line 3 shows that the average daily gain increased with the increased weights, and line 4 shows practically the same thing, or that the 175-pound pig requires less time to make 50 pounds of gain than the 125- or the 75-pound pig.

Line 5 shows that the dry matter per day for 100 pounds live weight is less for the 125-pound pig than for the 75- or 175-pound pig, though the difference is small.

Line 6 shows that the estimated food required for support increases with the increased weights of the pig, while in line 7 we see that the food of support in per cent. of live weight decreases with the increase in weight.

The food of support in per cent. of total food, as shown in line 8 is greatest with the 125-pound pig and least with the 175-pound pig. In making this calculation the food of support is reckoned for the average of food of support of maintenance periods immediately preceding and following the gain period

for which it is calculated, e. g., the food of support for the 50-pound pig is .72 pound and for the 150-pound pig is 1.72 pounds, average for 125-pound pig, 1.22 pound; in the case of 175-pound pig having no maintenance period following, a food of support for maintenance period immediately preceding only, or 1.8 pounds of dry matter per day was assumed.

The ninth line shows the ratio of dry matter in food of support to be greatest for the 175-pound pig, or to increase with the increasing weight of the pig.

The amount of food eaten for a given gain in weight increases materially with the increased weight of the pig, as shown by line 1 of the table. The daily food of support also increases, as in line 6, and this would tend to show that the 75-pound pig would be the most profitably fed, but in line 7 we see that the food of support in per cent. of live weight decreases with the increase in weight of the pig, and from line 3 that a larger daily gain is made, and this would prove the opposite, or that the 175-pound pig is fed at greater profit than either the 75- or 125-pound pig.

There was no difference between the several lots as to the feed requirements for a given gain.

DIGESTION TRIAL WITH PIGS.

Two digestion trials were made, one when the pigs were on the maintenance ration and weighing 150 pounds, and one when on full feed when weighing 125 pounds. The digestion factors secured with pigs during maintenance and when on full feed are shown in the following tables:

Digestion factors during maintenance.

	Dry matter.	Protein.	Nitrogen-free extract.	Ether extract.
	Per cent.	Per cent.	Per cent.	Per cent.
Little Berkshire	58.4	75.8	78.5	81.8
Little Razorback	43.3	72.7	77.1	80.
Big Razorback	50.8	78.7	80.1	81.8
Big Berkshire	65.7	75.8	79.3	86.3
Average co-efficients of digestion	54.6	75.8	78.8	82.5

Digestion factors during full feed.

	Dry matter.	Protein.	Nitrogen-free extract.	Ether extract.
	Per cent.	Per cent.	Per cent.	Per cent.
Little Berkshire	75.2	69.	88.7	72.7
Little Razorback	79.5	74.4	89.2	81.8
Big Razorback	77 5	75.7	89.4	72.7
B g Berkshire	81 5	76.4	89 4	86.3
Average co-efficients of digestion	78.4	73.9	89.2	78 4

Ash and crude fiber are not given in these tables nor is the coefficient for dry matter in the first table what it should be. This is because of the large amount of dirt eaten by the pigs when on maintenance. When the pigs were on full feed little or no dirt was eaten and the results shown in the second table are satisfactory, showing the nutrients digested to be as follows:

Dry matter 78.4 per cent., ether extract 78.4 per cent., protein 73.9 per cent., and nitrogen-free extract 89.2 per cent.

OFFICIAL TESTS OF DAIRY COWS, 1900-1901.

F. W. WOLL AND ROSCOE H. SHAW.

The work in this line during the past year has been conducted principally in conjunction with the Holstein-Friesian Association of America, although open to all breeders of pure-bred stock who care to avail themselves of the privilege. In all forty-five different tests have been made, since the publication of last report* and up to July 1, 1901, the tests ranging in length from one to forty-one days. One hundred and thirty cows were tested in all, belonging to fifteen different breeders. Only two breeds of cattle have been represented, *i. e.*, the Holstein-Friesian and the Guernsey.

We will first take up the official tests of Holstein-Friesian cows.

A. OFFICIAL TESTS OF HOLSTEIN-FRIESIAN COWS.

One hundred and twenty individual tests were made during the year. Of this number twelve cows were tested more than once. Forty-four of these individual tests were made on cows over five years old, sixteen on cows between four and five years old, twenty-four on cows between three and four years old, and thirty-six on cows under three years old.

The names and addresses of the different owners are given below, the numbers in each case referring to the "Cow No." in the subjoined tables.

M. S. Campbell, Genoa, Ill., Nos. 8, 21, 46 and 74.

A. C. Demerit, Lake Mills, Wis., Nos. 36 and 37.

Wm. Everson & Son, Lake Mills, Wis., Nos. 28, 29, 40, 47 and 76.

M. H. Gardner, Darien, Wis., Nos. 4, 5, 9, 48, 91, 93 and 94.

*Seventeenth Ann. Report, pp. 62-75.

W. R. Gates, Fort Atkinson, Wis., No. 56.

Gillett & Son, Rosendale, Wis., Nos. 69, 95, 96 and 97.

Nick Grimm, Clemansville, Wis., Nos. 10, 30, 31, 49, 77, 79 and 109.

S. B. Jones & Son, Hustisford, Wis., Nos. 18, 19, 20, 32, 33, 34, 39, 41, 52, 53, 54, 55, 59, 73, 83, 104, 105, 110, 111 and 118.

W. H. Jones, Hustisford, Wis., Nos. 1, 3, 11, 12, 13, 43, 61, 62, 64, 65, 70, 71, 84, 85, 86, 87, 90, 98, 99, 100, 119 and 120.

Frank B. Fargo, Lake Mills, Wis., Nos. 25, 26, 27, 57 and 108.

A. N. McGeoch, Lake Mills, Wis., Nos. 2, 6, 7, 14, 15, 16, 17, 22, 23, 24, 42, 45, 50, 51, 60, 61, 63, 66, 67, 68, 72, 75, 86, 87, 88, 89, 92, 101, 102, 103, 106 and 107.

E. C. Petrie, Bowers, Wis., Nos. 44 and 60.

E. E. Randall, Hustisford, Wis., Nos. 35, 38, 58, 78, 79, 80, 81, 82, 112, 113, 114, 115, 116 and 117.

In conducting the tests the station employed five young men, all graduates of our Short Course of Agriculture or our Dairy Course.

Chas. A. Nicolaus, Troy Centre, Wis., tested cows Nos. 1, 3, 6, 7, 9, 10, 14, 15, 16, 17, 21, 22, 23, 24, 32, 33, 34, 35, 36, 37, 38, 42, 44, 45, 48, 49, 50, 51, 58, 60, 61, 62, 63, 64, 65, 67, 68, 69, 72, 74, 75, 78, 79, 80, 81, 82, 85, 86, 87, 88, 89, 90, 92, 93, 94, 95, 96, 97, 101, 102, 103, 106, 107, 110, 111, 112, 113, 114, 115, 116 and 117.

J. M. Wagner, Hillsboro, Wis., tested cows Nos. 8, 11, 12, 13, 18, 19, 20, 28, 29, 40, 46, 47, 52, 53, 54, 55, 70, 71, 73, 76, 98, 99, 100, 104 and 105.

Roy T. Harris, Warrens, Wis., tested cows Nos. 30, 31, 39, 41, 43, 59, 77, 83, 84, 109, 118, 119 and 120.

L. P. Martiny, North Freedom, Wis., tested cows Nos. 25, 26, 27, 57 and 108.

P. A. Dukleth, Big Bend, Wis., tested cows Nos. 4, 5, 56 and 91.

At the completion of test No. 111, S. Hoxie, Superintendent of Advanced Registry, Yorkville, N. Y., ordered a retest of the cow Minnie Sandes 2nd, owned by S. B. Jones & Son, Hustisford, Wis. In compliance, Geo. A. Olson and J. M. Wagner went to Hustisford and conducted a three-day retest. During this time one or the other of the men was with the cow constantly. Their figures confirmed the previous seven-day test.

In the case of Melisse Clothilde (Test No. 7), upon request of C. A. Nicolaus, who was testing her, one of us (S.) visited the farm and personally investigated the conditions. In this case the cow showed variations in butter fat from 2.6% to 8.8% in thirty-six hours. This was a case of abnormal production, due in all probability to a slight attack of fever.

The results of official tests of Holstein-Friesian cattle are given in the following tables, which show the total yield of milk and butter fat for seven consecutive days, also the average percentage of fat in the milk for this period, the variations in the fat content of single milkings, the variations of daily yield of fat, and in most cases the body temperature of the cows during the test.

As the popularity of these tests has increased, the tendency among those breeders who have had most tests made, has been to continue the test longer than seven days and from this extended period select the seven best consecutive days to be reported to the Superintendent of Advanced Registry. This has been the case with nearly half the number of tests conducted this year.

While it is not the purpose at this time to discuss the results obtained, but rather to wait a few years until more data have been collected, it seems well to bring up one point which is always the cause of considerable discussion, viz., the variation in percentages of butter fat in milk from individual cows. It will be seen by a glance at the tables that the cows under test in general showed large variations in percentage of butter fat. This in some cases is so marked that in one milking the percentage may be more than double that of another; e. g., in case of cow No. 14, Duchess Ormsby 2nd, where the minimum is 2.3% and the maximum is 6.0%, and the cow No. 69, Jessie DeKol Burke, where the minimum is 2.0% and the maximum is 4.4%.

In most cases these differences cannot be explained, as their causes are not yet understood. It has been found, however, when cows are milked at irregular intervals that the milking succeeding the longest interval will, as a general rule, be poorest in butter fat and the milking following the shortest interval will be richest in butter fat; any change in the system of feeding, in the surroundings or treatment of the cow, or anything tending to irritate or excite the cow, will be apt to have an immediate effect of changing the quality of her milk, generally decreasing its fat content.

Records of official tests of Holstein-Friesian Cows, 1900-1901.

Cow No.	Name.	Registry No.	Test began	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Average per ct. fat.	Variation in Fat. Min.	Variation in Fat. Max	Fat per Day. Min.	Fat per Day. Max.	Body Temp. of Cows. Aver.	Body Temp. of Cows. Range.
	Class I — Cows five years old or over.			Y. M. D.		Lbs.	Lbs.	Per ct.	Per ct.	Per ct.	Lbs.	Lbs.	° F.	° F.
1	Dinah Aaltje	37,832	Oct. 13	6—6—11	11	317.6	9.018	2.81	2.67	3.18	1.11	1.49	....	....
2	Flora Belle Pietertje	39,322	Nov. 12	5—0—4	100	203.8	6.646	3.25	2.98	3.54	.83	1.13	100.9	100.6—1.5
3	Dinah Aaltje	37,842	Nov. 21	6—6—19	40	345.5	10.473	3.03	2.80	3.17	1.34	1.55	101.3	99.2—103.0
4	Daisy A. Mercedes	20,170	Dec. 1	11—6—29	25	343.8	11.490	3.43	2.4	4.3	1.53	2.10	....	....
5	Lady Flossy's Grace 2d	984*	Dec. 3	7—3—10	10	475.9	15.925	3.20	2.7	4.0	2.15	2.33	....	....
6	Bakker Bell 2d	22,523	Nov. 30	10—8—29	25	336.7	10.249	3.01	2.87	3.8	1.42	1.55	101.0	100.4—1.0
7	Melisse Clothilde	37,371	Dec. 7	7—3—11	7	[illegible]	13.147	4.39	3.51	5.88	1.64	2.53	101.6	101.2—2.4
8	Alfrida Clifden	1,441*	Dec. 30	6—0—25	28	368.8	12.223	3.31	3.23	3.45	1.69	1.80	....	....
9	Skilark Mercedes	29,018	Jan. 8	9—9—26	5	392.6	14.875	3.79	3.1	4.6	1.91	2.27	102.0	101.2—2.7
10	Aaggie Parna Clothilde	24,892	Feb. 6	10—5—28	14	418.5	12.320	2.95	2.2	4.0	1.65	1.95	102.1	101.4—3.0
11	Aaltje Salo Queen 2d	35,242	Jan. 21	7—8—23	22	376.2	11.465	3.05	2.87	3.17	1.56	1.72	....	....
12	Duchess Ormsby	16,004	Jan. 24	11—11—11	4	408.4	15.980	3.64	3.55	4.44	2.03	2.50	....	....
13	Lottie Lass 2d	44,120	Jan. 20	7—9—1	17	355.6	12.023	3.41	3.22	3.75	1.65	1.80	100.4	99.0—102.0
14	Duchess Ormsby 2d	35,419	Feb. 15	7—10—16	63	312.6	14.412	4.2	2.3	6.0	1.67	2.31	100.7	100.3—1.3
15	Aaltje Salo 5th Tritomia 2d	38,794	Feb. 15	5—6—7	3	336.6	11.544	3.41	1.2	5.8	.49	1.78	101.2	100.0—1.8
16	Piebe Laura	27,243	Feb. 15	9—9—1	3	369.6	14.194	3.84	2.8	5.6	1.29	2.25	101.5	99.8—101.8
17	Rixa Silva 3d Pietertje	31,258	Feb. 15	6—0—0	6	390.0	15.185	3.89	3.74	4.03	2.12	2.30	101.6	101.4—1.8
18	Jessie Fobes 4th	35,692	Feb. 6	6—9—23	15	514.8	18.0[illegible]7	3.5	3.27	3.67	2.51	2.68	102.1	101.5—2.8
19	Lilie of Wild Rose	28,774	Feb. 5	9—5—3	97	346.6	12.539	3.62	3.45	3.8	1.74	1.88	....	....
20	Wild Rose Jones 2d	37,859	Mar. 7	6—8—28	20	465.6	17.691	3.8	3.62	3.97	2.42	2.67	....	....
21	Aaggie De Kol	37,051	Mar. 14	6—7—27	43	359.9	13.424	3.73	2.8	4.4	1.78	2.08	....	....
22	Aaltje Salo 5th Tritomia 2d	38,799	Mar. 22	6—7—11	35	356.6	10.803	3.03	2.7	3.8	1.42	1.81	100.8	98.0—101.7
23	Pensa 5th Netherland	45,783	Mar. 22	5—1—22	28	345.5	12.0[illegible]8	3.47	2.6	5.0	1.54	2.06	100.9	100.0—1.7
24	Aaltje Salo 5th Tritomia	34,137	Mar. 25	8—6—22	4	403.0	14.52[illegible]	3.6	1.8	5.4	1.73	2.29	101.6	101.4—2.0
25	Aaggie Colanthus	39,5[illegible]3	Mar. 26	6—2—14	80	337.7	10.825	3.2	3.6	4.20	1.46	1.67	101.5	102.2—3.2
26	Sadie Aaggie	34,584	Mar. 26	7—10—29	67	329.9	12.660	3.84	3.67	3.95	1.75	1.87	102.0	101.6—2.6
27	Elbaja	20,020	Mar. 26	11—11—23	12	332.2	12.734	3.83	3.54	3.98	1.63	1.95	102.3	101.4—3.2
28	Lucyra	15,033	Mar. 25	12—9—24	17	423.2	15.690	3.71	3.1	4.6	2.18	2.27	102.4	102.0—2.9
29	Portland Queen	20,571	Mar. 25	11—10—0	15	424.6	15.370	3.32	3.0	5.55	2.12	2.23	102.7	102.3—3.3
30	Castine Carine Colantha 2d	41,155	Apr. 16	5—0—9	34	341.7	10.900	3.19	2.9	3.6	1.38	1.79	102.4	102.2—2.6
31	Aaggie Plaisante	43,348	Apr. 19	5—0—9	47	365.1	11.121	3.04	2.83	3.19	1.50	1.75	102.3	101.9—2.6
32	Lady Oak 2d	39,947	Apr. 18	6—0—23	29	418.5	15.505	3.71	3.0	4.6	2.13	2.35	101.2	100.2—1.6
33	Lady Oak	32,285	Apr. 18	9—1—16	59	355.9	13.917	3.61	3.0	4.5	1.83	2.05	101.9	101.4—2.2

* W. H. B.

34	Lady Longfield	32,290	Apr. 18	8—11— 9	10	473.8	16 910	3.57	2.6	4.8	2.19	2.73	102.3	101.8— 2.6
35	Alcatia 2d Rose	44,430	Apr. 2	8— 0— 0	9	318.5	12.433	3.9	3.3	5.0	1.60	1.87	102.2	101.3— 3.0
36	De Mar	20,022	May 14	11—10—24	15	322.7	10.587	3.28	2.7	4.0	1.46	1.61	....	....
37	Netherland Elbaja	29,861	May 14	10— 0—15	188	213.2	8.278	3.8	3.5	4.2	1.13	1.24	....	....
38	Wisconsin Bess	45,116	May 22	5— 9— 0	16	471.2	15.823	3.36	2 45	4.9	2.05	2.49	....	....
39	Lady Oak 2d	39,917	May 19	6— 2— 0	51	449.3	15.0.3	3.35	3 22	3 47	2 00	2.30	101.9	99.8—102 0
40	Francker Maid's Parmelia Pride	30,325	Jan. 9	8— 8—22	20	370 2	12.007	3.24	3.15	3.33	1.64	1.75	102.9	102 0— 4.1
41	Wild Rose Jones 2d	37,839	May 23	7— 0— 8	102	485.3	15.803	3 26	3.14	3.49	2.15	2.35	101.5	100 2— 2.2
42	Bakker Bell 2d	22,528	Nov. 12	10— 8—11	9	257 9	8.910	3.46	3.12	3.93	1 16	1.45	101.8	101.0— 2.0
43	Hello 4th's Pet	43,611	May 14	5— 7—24	12	632 9	19.934	3.26	2.91	3 87	2 21	3.12	102.7	202 1— 3.0
44	La Reina Bell Sir Henry	35,000	June 19	7— 2— 3	12	437.8	15.324	3 50	3 2	4.00	2 16	2.23	103.0	101.2— 4.0
	Average for 44 tests	....	....	....	33	379.5	13.244	3 49	1.2	6 0	.49	3.12	101.6	98.0—104.1
	Class II.—Cows four years old and under five.													
45	Bakker Bell Pietertje	41,995	Dec. 7	4— 8—16	17	323.1	11.362	3.52	3.25	3.82	1.52	1.73	100.9	100.0— 1 2
46	Duchess Pietertje De Kol	41,197	Dec. 30	4—11— 5	25	319.3	12.763	3.52	3.51	3.77	1.75	1.80	....	....
47	Genevra Colanthus	46,625	Jan. 9	4— 3— 6	10	417 7	16.713	4.0	3.83	4.09	2.33	2.49	101.9	101.5— 2.3
48	Daisy B. Mercedes 2d	42,057	Dec. 23	4— 8— 23	13	390.5	15 900	4.07	3.65	5.4	2.11	2.37	101.9	101.2— 2.6
49	Rylmo Echo's Girl 2d	45,918	Feb. 6	4— 1— 6	45	319 0	10 403	3 25	2 4	4.05	1.40	1.53	102.1	101.4— 2.6
50	Aaltje Solo Princess May	43,981	Feb. 23	4— 0—23	5	282.0	13.373	4.72	1.5	8.1	1.06	2 54	101 6	101.0— 2.4
51	Wit Duchess	43,953	Feb. 25	4— 5—19	5	293.2	12 239	4.17	2 8	5.8	.91	1.75	101.6	99.2—103.3
52	Jessie Fobes 2d Tritomia	44,130	Feb 25	4— 1—17	13	423.7	16.338	3.81	3 67	3.93	2 20	2.43	....	....
53	Jessie Fobes 2d Tritomia	44,131	Mar. 11	4— 2— 4	25	471.2	16.567	3.78	2.93	4.55	1 95	2.38	....	....
54	Blauch Frisby	44.132	Mar. 11	4— 0—23	10	357.7	13.123	3.67	3.57	3.70	1.80	1.95	....	....
55	Grace Fayne 2d	44,124	Mar. 10	4— 1—27	11	379.1	12.756	3.36	3 21	3.5	1.76	1.92	....	....
56	Hilda De Kol	43,955	Mar. 15	4— 5—29	21	400.2	13.437	3 33	3 16	3.67	1.83	1.96	102.6	102.3— 2.9
57	Kate Colanthus	43,114	Mar. 26	4— 3—23	81	355 8	11.283	3 2	3.02	3.6	1 53	1 72	102.4	101.8— 3.0
58	Minerva Netherland	44,435	Apr. 29	4— 4—29	20	245.9	11 420	3 83	3 0	4.4	1.57	1.74	102.4	101.8— 3.0
59	Jessie Fobes 2d Tritomia	44,130	May 19	4— 2—23	95	418.4	13.262	3.12	2.76	3.48	1.64	2.09	101 4	100.8— 2 1
60	Schadeland Mechthilde	50,187	June 19	4— 3—21	38	472.9	14.353	3.04	1.8	4.2	1.68	2. 1	102 7	101.8— 3.8
	Average for 16 tests	....	....	....	24	372.2	13 475	3.62	1.5	8.1	.90	2 54	101.9	99.2—103.8
	Class III.—Cows three years old but under four.													
61	Johanna B's De Kol Clothilde	49,453	Oct. 13	3— 2—17	30	234.3	6.325	2.82	2.45	3.18	.80	1.07	....	....
62	Akkrummer Aaggie Beck	44,677	Nov. 12	3— 7— 8	54	211.2	7 364	3.49	3.19	3.75	88	1.14	101.1	101.0— 1.8
63	May Ormsby	46,453	Nov. 12	3— 3—29	4	303 0	10 063	3.27	2.97	4 55	1.22	1.83	102 1	102.0— 2.4
64	Grace Hattie	48,835	Nov. 21	3— 1— 1	17	274 2	10 314	3 76	3.17	4.03	1.37	1.57	101 7	100.4— 2.8
65	Bell Rose Duchess	47,244	Nov. 21	3— 0— 3	28	248 0	10.111	3.30	3.14	3 72	1.39	1.52	101.5	997.0 —103 0
66	Akkrummer Aaggie Beck	44,677	Dec. 1	3— 7—26	41	250.9	8 875	3 54	3.21	4.08	.97	1.53	102 2	101 0— 2.8
67	May Ormsby	46,453	Dec. 6	3— 6—17	27	363.7	11.737	3.19	2.81	3.69	1.47	2.09	101.6	101 0— 3 0
68	Piebe Queen 2d Princess	45,007	Dec. 6	3— 8—19	7	259.3	10 392	4.03	3.66	4.53	1.33	1 75	102.3	101.8— 2.8
69	Jessie De Kol Burke	44,122	Jan. 16	3— 0— 3	74	292.1	9.683	3.36	2.0	4.4	1.29	1.50	....	....

Records of official tests of Holstein-Friesian Cows, 1900–1901—Continued.

Cow No.	Name.	Registry No.	Test began.	Age.	Days in milk.	Yield in Seven Days. Milk.	Yield in Seven Days. Fat.	Average per ct. fat.	Variation in Fat. Min.	Variation in Fat. Max.	Fat per Day. Min.	Fat per Day. Max.	Body Temp. of Cow. Aver.	Body Temp. of Cow. Range.
	Class III.—Cows three years old but under four—Con.			Y. M. D.		Lbs.	Lbs.	Per ct.	Per ct.	Per ct.	Lbs.	Lbs.	° F.	° F.
70	Jessie Fobes 2d Maud 2d........	41,123	Feb. 5	3— 9—11	7	374.0	14.508	3.88	3.69	4.05	1 99	2.08	101.4	100.5— 1.8
71	Lady Oak Fern..................	44,126	Jan. 27	3—10—23	11	379.0	14.034	3.71	3.49	3 81	1.95	2.07	101.0	99.5—101 8
72	Busacker........................	4[illegible],980	Feb. 15	3—11—25	52	291.3	9.746	3.35	2 4	4.75	1.19	1.54	101.2	101.0 — 3.0
73	Jessie Fobes 2d Myrtle..........	49,192	Feb. 5	3— 3—13	11	380.1	10 982	2.89	2.79	2 97	1.51	1.63	....	....
74	Lady Rhoda Coblenz..............	49,512	Mar. 14	3— 4— 7	39	265.9	9.066	3.41	2.7	4 5	1.21	1.39	102.4	101.5— 5.6
75	Jessie Parthenia................	49,597	Mar. 22	3—10—22	14	318.5	10.619	3.33	2.4	4.8	1 43	1.64	101.5	100.4— 5.0
76	Dorothy Pauline De Kol Wayne	45,123	Mar. 25	3— 2— 2	20	441 8	14.570	3.3	2.75	3.9	2.02	2.15	102.2	102.0— 2.4
77	Aaggie Carrene Parthena	48,488	Apr. 16	3— 2— 2	10	349.0	12.510	3.58	3.3	3 69	1.75	1.85	102.7	102 6— .8
78	Gemina Beauty Bell	48,167	Apr. 29	3— 7—11	55	300.4	9.537	3.17	2 8	3.5	1.27	1.45	102.8	101 0— 3.4
79	Ollie Watson 5th...............	48,168	Apr. 29	3— 0— 9	21	301.3	10.439	3.46	2.75	4 2	1.36	1 65	102.1	100.6— 2.8
80	Gemina Beauty Bell	48,167	Apr. 2	3— 0—14	28	325.2	10.973	3.37	2 6	4 0	1.45	1.75	101.4	101.1— 1.7
81	Fannie Douglas 4th's Pet..	48,161	Apr. 2	3— 0— 6	19	231.4	9.028	3.9	3.3	4.3	1.16	1.36	101.4	101.1— 1 8
82	Ollie Watson 5th...............	48,168	May 22	3— 1— 2	44	353.7	12.110	3.42	2 8	4 0	1.46	1.86	....	....
83	Minnie Sandes 2d	49,318	May 18	3— 0— 4	62	480.5	15.500	3 23	2.96	3.74	2.01	2.70	101.9	100.6— 3.1
84	Butterfly Netherlands	48,763	May 6	3— 0— 1	37	352.9	10.215	2.89	2 77	3.04	1.38	1.57	103.0	101.7— 3.9
	Average for 24 tests	....	....	....	31	317.8	10.770	3.39	2.0	4 8	.80	2.70	101.9	99·5—105.6
	Class IV.— Cows under three years old.													
85	Piebe Pauline De Kol.	50,434	Oct. 13	1— 8—17	17	241.5	7 681	3 18	3.00	3.41	1.02	1.19	101.4	100 6— 2.2
86	Rosebud Queen..................	48,764	Oct. 13	2— 5—17	107	186.7	5.819	3.12	3.07	3.29	.81	.86	....	....
87	Lady De Kol Hattie	49,845	Oct. 13	2— 0—15	64	175.	5.960	3.41	3 34	3.52	.83	.87	....	....
88	Liscomb Aaggie 3d..............	47,553	Nov. 12	2— 9—14	96	240.5	6.457	2.68	2.22	3.17	.79	1.08	101.1	99.0—102 0
89	Mechthilde Mink................	47,822	Nov. 12	2— 3—10	6	195.1	6.152	3.25	2.96	3.35	.82	.93	101.2	100.5— 2.2
90	Aaltje Salo Recka	49,337	Nov. 21	1—11—25	10	266.6	8.399	3 15	3 05	3 37	1.15	1.26	101.5	100.8— 2.4
91	Pietertje Maid of Grauw 2d	51,194	Dec. 1	1— 9—27	12	219.9	7.698	3.64	3.41	4.01	1.02	1.22	....	....
92	Mechthilde Mink................	47,822	Nov. 30	2— 3—28	31	225.6	6.992	3.1	2.2	4.2	.90	1.07	100 8	100.0— 2.0
93	Madge P. De Kol	51,195	Dec. 27	1— 9—12	16	266.8	8.436	3.16	2.65	3.6	1.13	1.32	102.1	101.6— 2.4
94	Hendrika Mercedes Pietertje...	49,670	Jan. 1	2— 4— 7	15	301.5	11.211	3 81	3.3	4 3	1.50	1.68	102.4	102.1— 2.8
95	Colantha 4th Johanna..........	48,577	Jan. 16	2— 2—16	48	355.9	12.024	3.38	2.85	4.35	1.62	1.82	....	....
96	Johanna De Pauline 2d.........	48,576	Jan. 16	2— 1—26	49	307.0	9.541	3.11	2.7	3.9	1.26	1 47	....	....

97	Johanna Colantha	48,578	Jan. 16	2— 3— 0	25	320.6	11.914	3.73	2.8	4.6	1.48	1.76	....	....
98	Jennie Pauline De Kol	51,079	Jan. 26	1—11—13	5	250.6	8.030	3.20	2.97	4.36	1.03	1.20	101.9	101.3— 2.6
99	Snowball Pauline	49,814	Jan. 17	2— 2—18	45	211.7	8.019	3.8	3.7	4.06	1.07	1.19	102.4	101.7— 2.6
100	Aaltje Salo Reka	49,337	Jan. 17	1—11—15	67	257.8	7.757	3.01	2.91	3.18	1.07	1.13	102.1	101.6— 2.6
101	Linda Laura	50,023	Feb. 15	2— 2—20	76	222.2	7.327	3.3	2.7	4.2	1.01	1.03	101.2	100.7— 1.8
102	Duchess Ormsby 4th	48,504	Feb. 15	2— 1—19	41	251.8	7.428	2.95	2.2	4.2	.96	1.28	100.9	100.3— 1.6
103	Flora Estata	50,024	Feb. 25	2— 4— 1	102	205.6	7.310	3.56	2.85	4.8	.97	1.09	101.5	101.0— 1.8
104	Almeda Luecke 2d	49,520	Feb. 20	2— 4—21	29	384.7	14.900	3.87	3.68	4.55	1.99	2.59	101.8	101.2— 3.6
105	Glen Rose De Kol	48,803	Feb. 17	2— 8— 0	15	403.1	13.816	3.43	3.28	3.54	1.91	2.03	101.8	101.2— 3.1
106	Ringwood De Kol	47,820	Mar. 22	2— 6—19	14	345.9	11.591	3.35	2.4	4.2	1.42	1.79	101.5	101.0— 1.8
107	Duchess Ormsby 4th	48,504	Mar. 22	2— 2—26	76	235.0	8.234	3.52	2.4	4.4	1.16	1.23	101.1	100.2— 1.7
108	Butter King's Butter Girl	57,281	Mar. 26	1— 2—26	9	242.4	7.346	3.03	2.71	3.2	.95	1.12	102.9	102.4— 3.6
109	May Lassie Rhoda	49,347	Apr. 16	2—10—21	39	278.8	9.150	3.28	3.00	3.55	1.17	1.45	102.6	102.2— 2.9
110	Jessie Maida	48,805	Apr. 18	2—10— 4	15	415.5	14.250	3.43	2.8	4.0	1.83	2.03	103.0	102.7— 3.3
111	Minnie Sandes 2d	49,318	Apr. 18	2—10—23	28	453.7	14.439	3.18	2.5	4.0	1.91	2.26	102.7	102.2— 3.3
112	Nig Alcartia 2d	48,402	Apr. 29	2—10—24	25	225.2	8.931	3.97	3.2	7.0	.85	1.65	103.9	103.2— 4.6
113	Francktje 2d's Maid	48,168	Apr. 29	2— 9—25	8	261.1	9.250	3.54	3.2	4.0	1.17	1.51	102.9	102.0— 4.6
114	Gewina Lulu Snowball	48,169	Apr. 2	2—11—24	29	213.4	9.867	4.62	4.1	5.4	1.33	1.53	101.1	100.6— 1.6
115	Alcartia Pokadot	50,798	May 22	2— 3— 2	20	336.5	12.550	3.73	2.1	6.4	1.51	1.94	....	....
116	Tiddledy Winks Maid 4th	48,165	May 22	2— 7— 2	10	301.6	11.021	3.65	2.0	5.4	1.41	1.89	....	....
117	Francetje 2d Maid	48,163	May 22	2—10—18	43	316.7	11.233	3.56	2.7	4.3	1.51	1.79	....	....
118	Jessie Maida	48,805	May 19	2—11— 5	46	417.2	13.067	3.13	3.03	3.23	1.81	1.96	101.7	100.6— 2.5
119	Cherry Pauline De Kol Duchess	52,922	May 4	1— 7—29	36	251.5	8.620	3.43	3.36	3.51	1.19	1.27	102.7	102.2— 3.4
120	Orleans De Kol Pauline	51,050	May 5	2— 1—27	46	275.3	8.461	3.07	2.99	3.17	1.18	1.26	102.4	101.9— 3.0
	Average for 36 tests	....	....	....	**37**	**279.7**	**9.471**	**3.39**	2.0	7.0	.79	2.59	101.9	99.0—104.6

A figure representing the daily average percentage of fat during the seven days of the test will vary much less than the single milkings (see p. 75). The average daily percentages for the cow Duchess Ormsby 2nd for this period were 44.4%, 4.62%, 4.14%, 4.21%, 3.90%, 4.19% and 3.94%. The average of these figures, 4.2%, differs but .42% from the highest daily percentage and from the lowest but .3%. In the second example taken, Jessie DeKol Burke, the seven daily averages are 3.53%, 3.16%, 3.08%, 3.05%, 3.43%, 3.53% and 3.44%, The highest of these daily averages, 3.53%, differs but .17% from the average of these figures, 3.36%, and the lowest but .31%.

If we could compare the figures representing the average percentage of butter fat per week of these two cows for a longer period, we should doubtless find that the variation from week to week at times would be even less, probably not more than .1%.

Moreover, these animals were under what may be termed "high tension" of feed. That is, they are fed that ration, which in the judgment of their owners will produce the very largest amount of milk during the period in which they are tested. Under such conditions it is a well known fact that cows are much more susceptible to a slight change in treatment or surroundings than is ordinarily the case.*

B. OFFICIAL TESTS OF GUERNSEY COWS.

In conjunction with the American Guernsey Cattle Club this Station conducted, during the year, one-day tests of six cows owned by Geo. C. Hill & Son, Rosendale, Wis., and a seven-day test of four cows owned by A. J. Philips, West Salem, Wis.

The former test differed from those reported in the preceding in that it consisted of tests of one day's duration only, conducted once every month. The methods of testing and sampling were identical with those already described, except that in taking composite samples five instead of one cubic centimeter of milk was taken, for each pound of milk. The Station Representative

*Some interesting variations of this kind are given in "Pan-American Dairy Record to July 16," by DeWitt Goodrich, in *Hoard's Dairyman*, July 26, 1901.

did not oversee a preliminary milking, and but two milkings per day were made. No notice was given the breeder as to the arrival of our Representative, and the test was conducted on no regular day each month.

These monthly tests were begun in May, 1900, when the herds of two Wisconsin breeders were tested. One of them, however, discontinued the test in July of the same year, while the test of the herd of Geo. C. Hill & Son was carried through the year. One of us made the May and December tests, and the others were conducted by Chas. A. Nicolaus.

The tabulated results of the tests made during the year are as follows:

Results of tests of Guernsey Cows, 1900–1901.

Cow No.	Name.	Reg. No.	May.			June.			July.			August.			September.			October.		
			Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct fat.	Fat. Lbs	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.
1	Nounon	6,569	33.1	4.14	1.357	35.8	4.2	1.505	33.6	5.1	1 715	23.5	5.06	1 186	23.6	5.3	1.251	15.8	6.32	1.078
2	Benjamin Primrose.......	7,820	26.1	5.28	1.420	22.5	5.65	1.273	15.7	6.0	1.045	3.4	4.97	1.690	4.8	5.89	.283	......	......	......
3	Primrose Tricksey.........	7,236	36.3	5.35	1.942	32.0	5.1	1.631	31.1	5.95	1.850	21.6	6.4	1.373	22.4	5.75	1.286	......	......	......
4	Lady Benjamin............	9,805	26.4	4.54	1.198	25.7	4.35	1.118	21.6	5.2	1.127	16.4	6.22	1.020	18.3	5.45	.997	14.5	6.09	.883
5	Gypsy of Racine...........	9,639	38.9	5.21	2.038	33.6	4.95	1.662	33.1	5 45	1.815	20.4	5 44	1.110	23.8	5.4	1.286	19.1	5.6	1.064
6	Lady Bishop..............	6,518	28.9	5.3	1.532	29.7	4.85	1.440	27.6	5.5	1.522	21 4	5.05	1.065	22.3	5.05	1.127	18.6	5.55	1.082

Cow. No.	Name.	Reg. No.	November.			December.			January.			February.			March.			April.		
			Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.	Milk. Lbs.	Pr ct fat.	Fat. Lbs.	Milk. Lbs.	Pr ct. fat.	Fat. Lbs.
1	Nounon	6,569	12.0	7.15	.858	12.3	6.4	.7832	13.9	6.61	.9186	9.5	7.69	.731	......	......	......	22.7	4.89	1,111
2	Benjamin Primrose.... ...	7,820	......	......	......	8.6	5 27	.4536	18.9	4.62	.8736	20.7	5.75	1.191	19.6	5.3	1.030	21.3	5.75	1.225
3	Primrose Tricksey.........	7,236	......	......	......	36.0	4.9	1.7658	36.0	4.69	1.6872	30.1	5.4	1.638	30.0	5.46	1.642	27.8	5 55	1.543
4	Lady Benjamin............	9,805	16.1	6.8	1.095	16.4	5.9	.9668	17.0	6.7	1.1390	15.0	6.32	.948	16.0	5.78	.925	16.1	6.41	1.032
5	Gypsy of Racine..........	9,639	14.2	5.6	.795	14.9	5.4	.8028	14 4	5.6	.8064	15.5	6.06	.940	16.6	5.3	.914	16.4	5.65	.926
6	Lady Bishop..........	6,518	16.2	6.06	.982	15.0	5.75	.8625	......	......	......	......	......	......	25.0	5.3	1.325	26.4	5.31	1.402

The complete records of the monthly data for milk and butter fat production for the best five of these cows, as secured by the breeder, are given in the Herd Register, published by the American Guernsey Cattle Club, vol. XI, part 47. The records show that the total production of milk and butter fat of the cows for the year 1900–'01 was as follows:

Production of milk and fat for the year 1900–'01.

	Milk.	Fat.		Dates of Calving.	Age.
	Lbs.	Lbs.	Per cent.		Years.
1. Primrose Tricksey...	9277.0	508.0	5.66	Jan. 14, '00...... Dec. 12, '00......	7
2. Gypsy of Racine.....	7879.1	432.8	5.53	Nov. 19, '99......	9
3. Lady Bishop.........	7272.4	394 3	5.02	April 16, '00..... May 5, '01.......	9
4. Lady Benjamin......	6815.5	390.9	5 87	April 15, '00......	4
5. Nounon	7059.5	382.8	5.81	May 8, '00....... April 6, '01.......	11
Average..............	**7660.7**	**421.8**	**5.58**		

The breeder received 2d prize in the Home Butter Tests for Guernseys, 1900–'01, for the herd of five cows given above, and the first two cows were awarded second and third prize, respectively, for single cows.

At a meeting of the Guernsey Cattle Club in June a system of Advanced Registry and Award of Prizes was adopted, which require seven-day official tests. During the same month the Station was called upon to furnish a man to conduct an official test under this new system, of the herd belonging to Mr. A. J. Philips of West Salem, Wis.; in accordance therewith Roy T. Harris was sent to West Salem; the results of his work are given below:

Seven-day tests of Guernsey cows, 1900–'01.

Cow No.	Name.	Registry No.	Test began	Age.	Days in milk.	Milk.	Fat.
						Lbs.	Lbs.
1	Queen Avis.........	11,096	June 2	2—11— 7	135	170.8	7.579
2	Yeksas Queen......	6,631	June 2	8— 8—15	91	277.1	12.703
3	Queen Det	11,430	June 2	2— 5— 1	86	179.0	7.923
4	Queen Dutte	9,794	June 2	4— 3—22	25	413.1	16.218

Seven day tests of Guernsey cows, 1900-'01— Continued.

Cow No.	Name.	Per Cent. Fat.		Fat Per Day.	Temp. of Cow.	
		Average.	Range.	Range.	Average.	Range.
				Lbs.	° F.	° F.
1	Queen Avis	4.44	3.58-4.88	.79-1.29	....	....
2	Yeksas Queen	4.58	3.14-5.48	1.14-2.07	101.6	101.1-1 9
3	Queen Det	4.43	4.17-4.62	1 06-1.21	....	....
4	Queen Dutte	3.93	3.49-4.45	2.04-2.72	102.1	101 7-2.4

As will be seen, breeders of Holstein-Friesian and Guernsey cattle were the only ones who this year availed themselves of the opportunity offered by the Station of having official tests conducted of pure-bred dairy cows owned by Wisconsin farmers. Last year Short-horn and Red Polled cows were also tested by us, and this fall inquiries from Jersey breeders have been received. The prospects are that a number of the various breeds of dairy cattle will be represented in these tests during the present year; the practice of securing accurate and unbiased evidence as to the maximum production of milk and butter fat of dairy cows by means of official tests will in time be likely to become general among breeders of pure-bred dairy cattle in this and other States of the Union.

ON THE AVERAGE COMPOSITION OF MILK OF PURE-BRED COWS OF DIFFERENT BREEDS.

F. W. WOLL.

During the year 1899–1900 the writer made complete chemical analyses of most of the composite samples taken by our Station representatives on the official tests of pure-bred dairy cows. It was believed that the analyses would furnish valuable contributions to our knowledge of the composition of milk of pure-bred cows of different breeds. The samples in a large majority of cases represented the average quality of milk produced by cows tested during a period of seven days, since an aliquot (1 cubic centimeter per pound of milk produced) was taken of each milking during the progress of the test. The variations from milking to milking and from day to day in this manner disappeared and the samples therefore represent, as nearly as possible, the average quality of milk of the cows at the time of testing. This was, in general, shortly after calving when the maximum production of butter fat is most apt to occur.

The results of the tests so far as the total production of milk and butter fat is concerned, and the general conditions under which the tests were conducted, have already been published in the 17th Annual Report of our Station.[1] The samples were in nearly all cases preserved by means of a potassium-bichromate tablet; these being of fairly constant weight (weighing very nearly 0.365 gr. each), and the volume of the composite samples being known in all cases, the per cent. of ash and of solids could be readily corrected for the bichromate added, and this was

[1] Pp. 68–75.

always done. No correction has been introduced for the specific gravity of the milk, however; the figures given in this column of the following tables are therefore too high, and no general averages have been calculated for this reason. The composite samples received in the official tests had at times been more or less churned out during transportation, but all samples subjected to complete chemical analysis were at least in fairly good condition. The methods of analysis followed were those adopted by the Association of Official Agricultural Chemists.[1]

The total solids and fat were determined by the asbestos method; the casein and albumen calculated from the total nitrogen as found by the Kjeldahl method, and the ash by drying and incinerating 5 cubic centimeters of milk on a flat porcelain dish in a muffle oven, while milk sugar was determined by difference, and the specific gravity by means of a Westphal balance. For the determination of solids 5 cubic centimeters were weighed into a perforated copper tube filled two-thirds full with stringy asbestos, and after drying and weighing, the fat was extracted by means of anhydrous ether distilled over sodium. The same pipette was used in measuring milk for the determination of solids, nitrogen and ash, and the weight obtained in weighing out the sample for solids was used for the last two determinations as well.

The results of the analyses of milk produced by Holstein-Friesian cows are given first, and these are followed by the analyses of milk from Guernsey, Short-horn and Red Polled cows.

A. *Holstein-Friesian cows.*—Seventy-eight samples of milk from seventy different Holstein-Friesian cows were analyzed. The analyses are arranged in the following tables according to the age of the cows, in the same way as in our last year's report, and summary data for all cows are given at the end.

[1]Bulletin 46, Revised Ed., U. S. Department of Agriculture, Division of Chemistry.

TABLE A.— *Composition of milk from Holstein-Friesian cows.*

Name of Cow.	Registry number.	Solids.	Fat.	Casein and albumen.	Milk sugar	Ash.	Solids not fat.	Sp. gr.	Milk per day.
Class I.— Mature Cows.		Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.		Lbs.
Ollie Watson	28,140	11 33	3.00	2 82	4.75	.76	8.33	35.1	40.8
Colantha 4th	35,028	11.62	3.36	3.07	4.44	.75	8.26	31.2	73.4
Johanna De Kol	36,478	11.97	3 52	3.05	4.67	.73	8.45	36 2	58.6
Alcarthia 2d Clothilde	44,431	11.71	3.41	3.04	4.42	.84	8.30	33.5	51.8
Wisconsin Pride	45,145	12.13	3.51	3 29	4.52	.81	8.62	35.3	47.7
Pietertje Lass	29,726	11.33	3.24	2.92	4.45	.72	8.09	33.6	51.8
May Rector	1,457	11 02	2 96	3.04	4.26	.76	8 06	31.8	67.4
Netta Netherl. Van Beers	46,877	11.79	3.41	3.36	4.16	.86	8.38	35.3	56.9
Aaltje Salo 5th Trit	34,137	11.07	2.96	3.11	4.13	.87	8.11	32.0	58 5
Melisse Clothilde	31,371	11.40	3.21	3.72	3.76	.71	8.19	30.9	60 2
Bell Pentour	20,361	11.31	3.04	3.12	4.39	.76	8.27	33.4	51.3
Rose Aaggie Liddisdale	1,413	10.95	3.15	3.15	3.90	.75	7.80	30.7	59.0
		11.41	3.24	2.47	4.96	.74	8.17	31.5	60.4
Duchess Ormsby 2d	35,439	12.79	3.93	3.76	4.33	.77	8.86	33.6	58.6
		11.73	3.31	3.05	4.64	.73	8 42	33.2	51.6
Piebe Laura	27,248	13.34	4.46	3.41	4.72	.75	8.88	36.2	53.2
		12.34	3.50	3.20	4.84	.76	8.84	34.2	55.3
Rixa Silva 3d Pietertje	37.258	12.49	3.55	3 83	4.30	.76	8.94	31.8	49.4
		11.81	3.12	3.00	4.96	.73	8.69	31.8	48.0
		11.89	3.27	3.12	4 80	.70	8.62	33.8	48.6
Johanna Aaggie	36,477	12.36	3.92	3.01	4.68	.75	8.44	33 1	57.6
		12 03	3.75	2 91	4 60	.74	8 28	32.8	56.9
Nina Melchior	24,500	12 31	3.73	3.36	4.36	.86	8.58	34.4	45.7
Linda Wit	20,072	12 31	3 43	3.33	4.82	.73	8.88	35 0	58.6
Netherl. Lucy Wit	48.996	11 87	3.38	3.03	4.78	.66	8.49	33.7	55.9
Piebe Queen	23,065	11.72	3.27	2.98	4.69	.78	8.45	33.4	53.4
Lady Oak 2d	39,947	13.13	3.95	3.57	4.88	.73	9.18	34.5	50.0
Lady Longfield	32,290	11.61	3 30	2.57	4.96	.78	8.31	33.0	52.4
Piebe 5th	35,246	11.36	3.20	3 24	4 17	.75	8 16	31.2	64.0
Aaltje Salo Princess 3d	38,802	11.63	3.43	3.13	4.27	.75	8.15	30.9	54.1
Bertha Boon Mercédes	39,320	12.43	3.35	8 28		.80	9.08	31.2	46.9
Lady Longfield 3d	39,945	10.95	2.98	2.92	4.19	.86	7.97	32.9	60.5
Lottie Lass 2d	44,120	11 67	3.31	3.16	4.41	.79	8.36	33.7	46.9
Average for 27 cows (32 samples)	....	**11.82**	**3.40**	**3.15**	**4.51**	**.76**	**8.42**	......	**54.7**
Class II.—Cows 4-5 years old									
Johanna Clothilde	40,384	12.26	3.93	2.80	4.76	.77	8.83	35.9	49.8
Greeting Helpless	44,437	13.23	4.03	3.20	5.13	.87	9 20	36.9	34.0
Ginger	40,757	10.30	2.77	3.17	3.63	.73	7.53	31.9	49.5
Lucy Wit 2d	44,231	12.22	3.57	3.34	4.55	.76	8.65	35.2	50 0
Sylva Thorns	42,079	11.36	3.39	2.73	4.54	.70	7.97	32.3	49.3
Rose Zoldusky Pauline	45,755	11.27	3.21	3.18	4.14	.74	8.06	32.5	47.9
Average for 6 cows (6 samples)		**11.77**	**3.48**	**3.07**	**4.46**	**.76**	**8.29**	......	**46.8**
Class III.—Cows 3-4 years old.									
Johanna De Pauline	42,169	12 68	4 32	3.16	4.43	.77	8.36	34 7	46.2
Johanna Rue 3d	42,167	11.75	3.48	3.03	4.45	.79	8.27	33.5	58.8
Lady Oak 3d	41,725	10 80	2 86	3 10	4.03	.78	7 94	35.0	57.7
Pietertje Lass 2d	50,657	12.41	3.63	3.41	4.61	.76	8.78	36.8	40.4
Bakker Bell Pietertje	41,995	12.70	3.63	3 66	4 63	.78	9 07	35.8	43.2
Jessie Fobes 2d Tritomia	44,130	12.41	3.49	2.98	5.06	.88	8.92	34.7	54.1
Grace Fayne 2d	44,124	11.91	3.09	3.72	4.18	.92	8.82	33.8	48.3
		11.56	3.21	3.55	4.13	.67	8.35	32.7	49.1
Fanny Douglass 4th	41.913	11.86	3 17	3.47	4.46	.76	8.69	34.9	45.9
Aaltje Salo Tritomia	43,979	11.19	2.94	3.08	4.52	.65	8.25	33.3	34.8
Wit Duchess	43,953	10.98	2.23	2.99	4.97	.79	8.75	35.6	50.8
		11.35	2.91	3.05	4.68	.71	8.44	33.1	44.4
Husky Josephine	43,983	11.30	2.76	3.23	4.53	.78	8.54	33.6	45.

TABLE A.—*Composition of milk from Holstein-Friesian cows*—Con.

Name of Cow.	Registry No.	Solids.	Fat.	Casein and albumen.	Milk sugar	Ash.	Solids not fat.	Sp. gr.	Milk per day.
		Per ct.	Pr ct.	Prct.	Prct.	Pr ct.	Pr ct.		Lbs.
Rijanetta Clothilde..........	42,949	12.97	4.13	3.21	4 74	.89	8.84	35.9	43.1
Lill Black's Pietertje........	45,976	11.92	3 29	3.24	4.62	.77	8.63	34.5	35.0
Jess De Kol..................	45,977	11.73	3 53	2.93	4.53	.74	8 20	32.1	38.1
Melisse Clothilde 2d..........	42,812	10 60	2.86	2.99	3.96	.79	7 74	30.6	56 8
Lady Longfield 4th...........	44,125	11.50	3.36	2.99	4.53	.62	8.14	32.5	55.9
Jessie Parthenia.............	49,597	12.03	3.28	3.26	4.76	.73	8.75	34.3	37.1
Jessie Griefe................	44,153	11.83	3.32	3.26	4.49	.76	8.51	33.7	42.2
Minerva Netherland.........	44,435	11.83	3.34	3.09	4.68	.72	8.49	33.0	43.7
Schadeland Mechthilde......	50,187	11.32	2.99	7.58		.75	8.33	31.3	61.2
Average for 20 cows (21 samples)...............		**11.78**	**3.28**	**3.21**	**4.52**	**.77**	**8.50**	......	**46.9**
Class IV.—Cows under 3 years old.									
Johanna Rue 4................	45,166	11 75	3.20	2.91	4.90	.74	8.55	34.6	45.4
Hartzog Nether. Inca Piet...	44,781	11.86	3.08	3 29	4.73	.76	8.78	36.5	48.6
Almedia Tritomia............	44,129	11.75	3 46	2.93	4.58	.78	8.29	35.8	33.9
Netherland Johanna Rue . .	46,877	11.68	2.93	3.27	4.68	.80	8.75	36.3	36.7
May Ormsby................. .	46,453	11.09	3.12	3.53	3.59	.85	7.97	34.0	32.6
Aaggie Gerben................	46,373	11.55	2.80	3.82	4.27	.66	8.75	34 3	45.6
Aaltje Salo Princess May.....	43,981	12.90	3.75	4.26	4.19	.70	9.15	35.0	35.1
Piebe Queen 2nd Princess....	45,007	12.14	3.55	3.28	4.51	.80	8.59	34 2	41.3
Johanna De Kol 3rd..........	45,167	13.05	3.99	3.44	4 86	.76	9.06	34.4	40.2
Lottie Douglas 2nd Pride....	44,769	10.92	2.99	2.95	4.35	.63	7.93	31.0	35.6
Jessie Maida.................	48,805	11 22	2.97	3.30	4.32	.63	8.25	32 8	37.7
Minnie Sandes 2nd..........	49,318	11.37	3.13	2.71	4.88	.65	8.24	32.8	37.5
Johanna Aaggie 2nd..........	45,165	11.99	3.23	3.13	4.98	.65	8.76	34.1	36.2
Aaltje Salo Aug. 2nd.........	46,798	11.51	3.24	3.13	4.45	.69	8.27	31.4	33.3
Akkrummer Elenera.........	46,796	11.52	3.24	3.15	4.44	.69	8.28	32.2	33.0
Belle Capitaine Mechthilde.	50 186	10.94	2 64	7.52		.78	8.70	31.8	43.7
Schoone Princess De Kol.....	46,799	10.76	2.73	3 06	4.21	.73	8 03	31.6	42.5
Average for 17 cows (16 samples)....		**11.69**	**3.21**	**3.26**	**4.50**	**.72**	**8.48**	. ....	**38.8**

B. *Guernsey cows.*—The milk from only two cows was analyzed, eleven analyses being made of that of Gypsy of Racine (No. 9639), and one of milk produced by Madame Tricksey (No. 6519). The samples were composites of two to six days' milkings, except No. 3, which was taken of a noon milking; Nos. 4 and 7, which represented single evening milkings, and Nos. 5 and 8, which represented single morning milkings.

TABLE B.— *Composition of milk from Guernsey cows.*

Name of cow.	Reg. No.	Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Sp. gr.	Milk per day
		Pr ct.	Pr ct.	Pr ct.	Pr ct	Pr ct	Pr ct.		Lbs.
Gypsy of Racine	9,639	13.88	5.27	3.26	4.56	.79	8.61	32.7	36.7
		14.17	5.08	3.47	4.85	.77	9.09	33.0	43.7
		13.85	5.14	3.82	4.67	.72	8.71	33.7	14 3
		13.40	4.62	3.17	4.74	.87	8.78	33 7	12.7
		13.77	5.13	3.34	4.46	.84	8.64	33.3	16.4
		14.31	5.36	3.65	4 56	.74	8.95	34.3	....
		14.72	5.39	3.30	5 20	.83	9.33	34.4	17.5
		15.06	5.67	3.51	5.03	.85	9.39	34.7	19.1
		14.53	5.43	3.42	4.90	.78	9.10	34.9	36.8
		14.36	5.34	3.39	4.89	.74	9.02	34.1	31.9
		14.67	5.24	3.42	5.17	.84	9.43	....	38.9
Av. for 11 samples..	......	**14.25**	**5.24**	**3.39**	**4.82**	**.80**	**9.01**	....	....
Madam Tricksey ...	6,519	16.82	6.98	4.12	4.95	.77	9.84	35.4	9.4
Av. for 2 cows (12 samples)..........	......	**14.46**	**5.39**	**3.45**	**4.83**	**.79**	**9.07**	....	....

C. *Shorthorn cows.*—Only two composite milk samples from Shorthorn cows were analyzed, with results as shown below:

TABLE C.—*Composition of milk from Shorthorn cows.*

Name of cow.	Reg. No.	Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Sp. gr.	Milk per day
		Pr ct.	Pr ct.	Pr ct.	Pr ct.	P ct.	Pr ct.		Lbs.
Reddie 1st	......	12.77	3.55	3.74	4 56	.92	9 22	37.4	29.3
Reddie 2d	......	12.43	3.48	3.33	4.70	.92	8.95	36.5	32.6
Av. for 2 cows (2 samples)..........	......	**12.60**	**3.52**	**3.53**	**4.63**	**.92**	**9.08**	....	**30.95**

D. *Red-Polled cows.*—Eight Red-Polled cows furnished composite samples of two full days' milkings.

TABLE D.—*Composition of milk from Red-Polled cows.*

	Reg. No.	Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Sp. gr.	Milk per day
		Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct	Pr ct.		Lbs.
Nora	11,648	12.43	3.63	3.54	4.53	.73	8.80	34.4	25.2
Jule......	11,378	12.00	3.55	3.17	4.55	73	8.45	33.3	35.3
Duchess of Centreville........	5,424	12 56	3.72	3.04	5.06	.74	8.84	34.7	33.5
Rosette..........	8,941	12.86	4.00	3.49	4.60	.77	8 86	33.6	22.2
Hetty 2nd.......	11,341	13 28	4.13	3.41	5.01	.73	9.15	34.3	21 2
Honor 3rd.......	11,347	12.20	3.38	3.50	4.57	.75	8.82	33.6	22 9
Violet Cone.....	12,372	13.25	4.21	3.24	5.05	.75	9.04	36.6	23.5
Joyce...........	8,624	12.00	3 30	3.33	4.65	.72	8.70	33.8	25.6
Av. for 8 cows (8 samples)..	....	**12.57**	**3.74**	**3.34**	**4.75**	**.74**	**8.83**	....	**26.2**

The following summaries of the results of the analyses for all breeds given in the preceding are here presented. The summaries are made up of samples from eighty-two cows, furnishing ninety-seven samples in all.

Summary table of the composition of milk of pure-bred cows.

	Number of		Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Fat in solids.	Milk pr day.
	Cows	Analyses.								
			Pr ct.	Prct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Lbs.
Holst'in-Fries'n	70	75	11.78	3.33	3.18	4.52	.75	8.45	28.3	48.4
Guernsey........	2	12	14.46	5.39	3.45	4.83	.79	9.07	37.3	....
Shorthorn	2	2	12.60	3.52	3.53	4.63	.92	9.08	27.9	31.0
Red Polled......	8	8	12.57	3.74	3.34	4.75	.74	8.83	29.7	26.2

Discussion of results.—The general average for the samples of milk from Holstein-Friesian cows came at 3.33 per cent. fat and 8.45 per cent. solids not fat. This is a slightly lower fat content than the average for all one hundred and twenty-one composite samples tested during the year, which was 3.41 per cent. As given in the tables published in our 17th Annual Report, there was a range in the fat contents of single milkings from 1.5 to 7 per cent. The preceding tables show the fat contents of the separate composite samples for seven days to range between 2.23 and 4.46 per cent.

The average fat content of 3.41 per cent. was for milk from cows 45 days from calving, on the average. The fat content of the milk at this time may be considered slightly above the average for the whole period of lactation; in general the milk produced by a cow is higher in fat for a month or two after calving, and when the milk secretion is beginning to diminish perceptibly prior to going dry before next calving, than during the intervening period. The evidence at hand goes to show that the average quality of milk from pure-bred Holstein-Friesian cows in this country will not vary greatly from 3.3 per cent. (See below.)

The average solids not fat of the Holstein milk (8.45 per cent.) is perhaps lower than might be expected. It will be seen, however, that the averages for all classes come very near

this figure, and none higher than 8.50 per cent.; only six analyses out of 78 came above 9 per cent., while seven analyses came below 8 per cent. Holstein milk has generally a lower fat content than the milk from cows of other breeds, but the total solids are made up of a larger percentage of fat than milk of similar richness of other breeds, as is shown in the column marked "Fat in solids." As a general rule, the lower the per cent. of fat in a sample of milk the smaller the proportion of fat in the solids, but the solids in the samples of Holstein milk analyzed contain 28.3 per cent. of fat, while those in the Shorthorn milk consist of 27.9 per cent. of fat, although the average fat content of this milk is two-tenths higher than that of the Holstein milk.

The number of samples of milk from the last three breeds given in the last table is too small to make a discussion of the data obtained of much value. In looking for further information as to the average quality of the milk of these breeds and of other breeds not represented in the table, one is surprised to find comparatively few complete analyses of milk from pure-bred cows on record. Single analyses of such milk are occasionally given in the dairy literature, but the samples in the majority of cases are made up of single or at best a few milkings of individual cows, and neither as to the number of milkings, nor of the number of animals included, can the data be considered representative of the various breeds.

The following table is submitted at this time embodying average data as to the chemical composition of the milk from our main American dairy breeds. The fat is commercially the most important component of milk and in order to furnish as reliable information as possible in regard to the average quality of milk from cows belonging to the various dairy breeds, analyses recorded in our dairy literature have been included even where no further information is given as to the composition of the milk produced than its fat content. No claim for completeness is made as to the analyses included in these summaries, although it is believed that the main data on record have been included for all breeds except perhaps the Holstein-Friesian, which, as it is, furnishes over one-third of the analyses.

The data presented in the table are obtained from the following sources:

I. Breed Test No. 1, World's Columbian Exposition, 1893 (75 cows; duration of test, 15 days).

II. Breed Tests, Pan-American Exposition, 1901 (50 cows, 183 days).

III. Breed Tests Conducted at American Experiment Stations (Compilation by Woll, Handbook for Farmers and Dairymen, Revised ed., p. 209; 45 cows, 72 lactation periods).

IV. Official Tests of Dairy Cows, Wisconsin Experiment Station, Report XI, p. 205.

V. Official Tests of Dairy Cows, Wisconsin Experiment Station, Report XIII, p. 154.

VI. Official Tests of Dairy Cows, Wisconsin Experiment Station, Report XVI, p. 149.

VII. Official Tests of Dairy Cows, Wisconsin Experiment Station, Report XVII, p. 62.

VIII. Official Tests of Dairy Cows, Wisconsin Experiment Station, Report XVIII.

IX. Official Tests of Holstein-Friesian Cows, Cornell (N. Y.) Experiment Station, Bulletin 152.

X. Geneva (N. Y.) Experiment Station, Report IV, p. 285.

XI. Wisconsin Experiment Station, Report IV, p. 164, and VII, pp. 118–119.

XII. Minnesota Experiment Station, Bulletin '67.

XIII. Vermont Experiment Station, Report XIII, p. 448.

XIIIa. Iowa Experiment Station, Bulletin 15.

XIV. Tests at State Fairs; Woll, Handbook for Farmers and Dairymen, p. 211.

XV. Milking Trials Conducted by the British Dairy Farmers' Association for 1879–'98 (Compilation by Woll, ibid., p. 212; 785 cows).

XVI. Dietrich & König, Zusammensetzung und Verdaulichkeit der Futtermittel, 2d ed., vol. I, p. 798.

XVII. Fleischmann, The Book of the Dairy, p. 43.

Average composition of milk of cows of different breeds.

Breed.	Total No. of Cows.	Total No. of Analyses.	Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Average daily milk yield.	References.
			Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Lbs.	
1. Jersey	28	......	14.77	5.40	3.64	5.67		9.37	12.7	XI
	......	31	14.10	4.32	3.34	5.70	.74	9.78	......	XVI
	25	......	14.12	4.53	......	......	......	9.59	35.6	I
	3	28	15.29	5.13	......	......	......	10.16	32.7	X
	272	......	14.46	4.98	......	......	......	9.48	28.9	XV
	24	......	14.60	4.91	......	......	......	9.69	......	XVII
	5	......	13.96	4.58	......	......	......	9.38	24.5	II
	4	4*	15.27	5.75	......	......	......	9.52	18.4	XIII
	25	83	14.67	5.12	......	......	......	9.55	23.5†	XI
	9	18*	......	5.40	......	......	......	......	......	III
	4	4*	......	5.02	......	......	......	......	19.0	XII
	7	......	......	5.03	......	......	......	......	39.9	XIV
	54	......	......	5.34	......	......	......	......	23.8	IV
2. Guernsey	2	12	14.46	5.39	3.45	4.83	.79	9.07	......	VIII
	7	......	14.74	5.20	4.08	5.46		9.54	23.5‡	XI
	......	26	14.61	5.11	3.98	4.38	1.14?	9.50	......	XVI
	25	......	13.74	4.56	......	......	......	9.18	29.2	I
	98	......	13.50	4.61	......	......	......	8.89	30.6	XV
	8	10*	......	5.20	......	......	......	......	......	III
	5	......	13.92	4.60	......	......	......	9.32	29.6	II
	3	3*	......	5.42	......	......	......	......	14.7	XII
	1	......	......	4.94	......	......	......	......	43.5	XIV
	1	......	......	6.31	......	......	......	......	24.1	IV
	5	......	......	5.58	......	......	......	......	28.1	V
	10	......	......	5.07	......	......	......	......	28.0	VIII
3. Holstein-Friesian	70	75	11.78	3.33	3.18	4.52	.75	8.45	48.2	VIII
	9	......	11.81	3.17	3.26	5.38		8.64	25.2	XI
	......	24	11.96	3.25	3.99	4.16	.56	8.71	......	XVI
	10	......	12.25	3.41	......	......	......	8.84	45.2	XV
	5	......	12.08	3.25	......	......	......	8.83	42.9	II
	143	......	11.91	3.23	......	......	......	8.68	......	XVII
	9	10*	......	3.43	......	......	......	......	......	III
	121	......	......	3.41	......	......	......	......	45.8	VII
	120	......	......	3.46	......	......	......	......	48.0	VIII
	210	......	......	3.16	......	......	......	......	52.3	IX
	4	4*	......	3.27	......	......	......	......	25.7	XII
	15	......	......	3.36	......	......	......	......	47.9	IV
	9	......	......	2.95	......	......	......	......	62.8	XIV
4. Shorthorn	2	2	12.60	3.52	3.53	4.63	.92	9.08	31.0	VIII
	......	67	12.80	3.47	3.21	5.43	.69	9.33	......	XVI
	25	......	12.68	3.58	......	......	......	9.10	32.5	I
	236	......	12.72	3.75	......	......	......	8.97	45.4	XV
	21	......	13.95	4.52	......	......	......	9.43	......	XVII
	3	......	12.49	3.51	......	......	......	8.98	24.3	XIIIa
	5	......	12.84	3.57	......	......	......	9.27	34.8	II
	4	5*	......	3.97	......	......	......	......	......	III
	4	......	......	3.29	......	......	......	......	31.0	IV
5. Ayrshire	......	43	13.07	3.58	3.42	5.43	.64	9.49	......	XVI
	13	......	13.02	4.13	3.34	5.55		8.89	25.9‖	XI
	32	......	13.29	4.19	......			9.10	42.2	XV
	5	......	12.69	3.60	......	......	......	9.09	36.1	II
	10	20*	......	3.60	......	......	......	......	......	III
	5	5*	12.58	3.90	......	......	......	8.68	21.9	XIII

* Lactation periods.
† 23 cows.
‡ 1 cow.
‖ 8 cows.

Average composition of milk of cows of different breeds—Con.

Breed.	Total No. of— Cows.	Analyses.	Solids.	Fat.	Casein and albumen.	Milk sugar.	Ash.	Solids not fat.	Average daily milk yield.	References.
			Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Lbs.	
6. Red Polled	8	8	12.57	3.74	3.34	4.75	.74	8.83	26.2	VIII
	35	......	12.55	3.68	......	......	......	8.87	42.9	XV
	5	......	13.14	3.98	......	.....	......	9.16	31.4	II
	2	2	......	3.85	......	......	......	......	16.5	XI
7. Brown Swiss	......	6	12 74	3.79	2.64	5 81	.70	8.95	.....	XVI
	5	......	12.76	3.63	.....	......	......	9.13	33.8	II
	7	......	......	3.87	......	......	......	......	35.5	VI
	1	1*	......	3.44	......	.....	......	......	22.2	XII
	1	9	......	3.81	......	......	......	......	81.7	XIV
8. Devon	......	20	13.43	4.44	......	......	.64	8 99	.....	XVI
	25	......	12.90	4.65	......	......	......	8.25	11.8	XI
	3	5*	......	4.60	......	......	......	......	......	III
	2	......	14.31	4.90	......	....	......	9.44	30.1	XV
9. Dutch Belted	5	......	12.31	3.40	......	......	......	8.91	27.2	II
10. Polled Jersey	5	......	13.93	4.66	......	......	......	9 27	22.9	II
11. French Canadian	5	......	13 32	3.99	....	......	......	9.33	27.0	II

* Lactation periods.

In order to obtain definite information as to the average quality of milk of the breeds enumerated above, the fat content has in each case been multiplied by the number of cows furnishing the milk. The products thus obtained are added together, and the sum divided by the total number of cows. As an appreciable number of determinations is only at hand for the fat contents and the average daily yields of milk, averages have only been calculated for these data, and since the milk yield is not given in some cases where the fat content is, the number of cows contributing to the averages is given in both cases. Having these two sets of average figures in case of the different breeds, multiplications have been carried out which show the average daily yield of fat for cows of the different breeds. The following table gives the summary data arrived at.

Average per cent. of fat and production of milk and butter fat per breed — all analyses.

Breed.	No. of cows.	Per cent. fat.	No. of cows.	Average daily milk yield.	Average daily fat yield.
				Lbs.	Lbs.
Jersey	491	4.98	425	27.3	1.36
Guernsey	191	4.77	151	29.7	1.42
Holstein-Friesian	679	3.28	503	48.8	1.60
Shorthorn	370	3 73	275	43.5	1.62
Ayrshire	108	3.84	50	37.0	1.42
Red Polled	50	3.73	50	37.3	1.39
Brown Swiss	20	3.78	14	37.3	1.41
Devon	50	4.57	27	13.2	.60
Dutch Belted		3.40	5	27.2	.92
Polled Jersey	5	4.66	5	22.3	1.07
French Canadian	5	3.99	5	27.0	1.08

The total number of cows contributing to the average percentages of fat given in this table is 1,974, and the number contributing to the milk yields 1,510. Owing to the large number of analyses making up these average data, the results may be considered representative for the main dairy or dual-purpose breeds, and as such should possess considerable value. We notice that the breeds rank in the following order as regards the richness of the milk produced, viz.: Jerseys, Guernsey, Polled Jersey, Devon, French Canadian, Ayrshire, Brown Swiss, Shorthorn, Red Polled, Dutch Belted, and Holstein-Friesian, and as regards the average daily production of butter fat: Shorthorn, Holstein-Friesian, Guernsey, Ayrshire, Brown Swiss, Red Polled, Jersey, French Canadian, Polled Jersey, Dutch Belted, and Devon. In drawing conclusions from these results it should be borne in mind:

First, the number of cows included under each breed varies greatly, and in case of three of the breeds the number is too small to give the data general value.

Secondly, the amount of milk and butter fat which a cow will produce stands in a definite relation to her live weight; when the production of a number of good dairy cows is compared, it will be found that the heavier the cows are the more

milk and butter fat will they in general produce in a given time, under otherwise similar conditions; we notice that the average yield of fat produced, as given in the preceding table, as a rule stands in fairly direct ratio to the average live weights of cows of the different breeds.*

Thirdly, the tests during which the cows produced these results varied in length from a couple of days to one or more whole lactation periods. Nearly all data for the Holstein-Friesian cows were obtained in seven-day tests; the records in the English Milking Trials (XV) were made during three-day tests, which would influence mainly the data for the Jerseys, Guernseys, and Shorthorns; the other breeds had a proportionally large number of cows on long-continued tests conducted under more normal conditions of feeding and care than those of short tests can ever be.

It may be objected that since the analyses and data given above are obtained from so many different sources, including British and Continental European figures, they do not fairly represent American conditions, and should not be used for comparison of the merits of our main dairy breeds. That this objection is in order is especially shown in case of the Shorthorn cows included in the summary: average per cent. of fat, 3.73; average daily milk yield, 43.5 lbs.; average daily fat production, 1.62 lbs. Nobody will perhaps maintain that nearly four hundred cows of this breed could be selected in this country which would be able to even approximate this performance; the high average comes from the records made by Shorthorns in the milking trials of the British Dairy Farmers' Association (average per cent. of fat 3.75, average daily milk yield 45.4 lbs.; see p. 93). In order to do away with the objection raised, all American data contributing to the preceding summaries have been compiled by themselves in the same manner as before. The results of these compilations are given in the following table:

*This subject has recently been quite fully treated by the writer in Breeder's Gazette, Sept. 5 to Oct. 3, 1900.

Summaries of American analyses.

Breed.	No. of cows.	Per cent. of fat.	No. of cows.	Average daily milk yield.	Average yield of fat.
				Lbs.	Lbs.
Jersey	164	5.13	153	21.5	1.26
Guernsey	67	4.87	53	28.9	1.41
Holstein-Friesian	502	3.30	493	48.9	1.61
Shorthorn	43	3.58	39	31.9	1.14
Ayrshire	33	3 85	18	27.7	1.07
Red Polled	15	3.84	15	26.6	1.02
Brown Swiss	14	3.77	14	37.3	1.41
Dutch Belted	5	3 40	5	27.2	.92
Devon	28	4.61	25	11.8	.55
Polled Jersey	5	4.66	5	22.9	1 07
French Canadian	5	3 99	5	27.0	1.08

This table is summarized from data for the average fat content of the milk from 881 pure-bred cows and for the average milk yields of 825 cows. In comparing the average yields of the different breeds the points mentioned above should be given due weight. The character of the tests of the Holstein-Friesian cows in the large majority of cases differs from those of most of the other breeds, the tests being of short duration and conducted under a more or less forced system of feeding. The large number of animals contributing to the average data for this breed renders the figures valuable as an expression of the average quality of the milk of American Holstein-Friesian cows and their production of milk and butter fat at the present time; the latter figures may be considered maximum when the performance of a large number of animals is summarized.

ANNUAL MILK AND BUTTER PRODUCTION OF COWS OWNED BY PATRONS OF THE UNIVERSITY CREAMERY.

E. H. FARRINGTON.

For the five years preceding 1901, the Dairy Department of the University has been supplied with milk from about 400 cows on fifty to sixty farms within eight miles of the Dairy Building. During the present year a new territory of about thirty farms was added to our patronage, and this has increased the milk receipts about forty per cent. Our milk supply has ranged from 3,000 to 13,000 pounds per day and has been received daily, except Sundays. In the winter it is used for the instruction of our 120 dairy students in butter and cheese making; during the remainder of the year it is available for making investigations and experiments, the results of some of which have already been published in reports and bulletins of this Station.

In our eight years of experience we have become familiar with the effects of competition, as well as the other every-day affairs of a practical creamery or cheese factory in this state. The amount of milk received has always been subject to the usual fluctuations caused by competition, drought, etc. Some milk has been diverted to other factories started near the farms of our patrons, as in June, 1896, a co-operative creamery was organized among some of our patrons and a former dairy student engaged to run the factory. The milk from several farms that were our patrons, has also been taken by retail milkmen, and the effects of hot weather, flies, severe drought, changes in feed, and seasons are plainly shown by our milk records for each year.

Our dealings with the patrons differ from the usual creamery practice in two particulars, which operate against us when a patron is considering which factory he will patronize:

First. We do not receive milk on Sundays. This makes it necessary for the farmer to buy some extra milk cans in which to keep the Sunday milk; he may also occasionally lose a can of milk which is refused at the creamery if it is sour Monday morning on account of his lack of facilities for taking good care of it. In warm weather farmers generally prefer to deliver their milk to a factory on Sunday rather than to supply the necessary tanks, cans and cold water for keeping it sweet until Monday.

Second. Our dairy school instruction requires a six-days-per-week delivery of milk during the winter months. This is not the case with creameries in general, where an every-other-day delivery is the common practice, and this is much preferred by the patrons on account of the saving in delivery trips during cold weather.

Milk supply of the university creamery, 1894–1901.—During 1894, the first year that milk was received daily, about thirty farmers supplied from two to four thousand pounds of milk per day. After this there was a steady increase in the quantity of milk until it reached its maximum of 13,000 pounds per day from 95 farms in May and June, 1901.

The fluctuations in the amount of milk received will be seen from the following table, which gives a monthly record of the milk supply for the past eight years:

Milk supply of the University Creamery, April, 1894, to October, 1901.

MONTH.	No. of patrons.	Milk.	Test of milk.	Elgin price.*	PAID THE PATRONS. Per pound butter fat.	PAID THE PATRONS. Per 100 lbs. milk (avé).	PAID THE PATRONS. For milk.
January.		Lbs.		Cents.	Cents.		
1894	......	......	......	......	......	......	......
1895	47	151,588	4.2	22.9	35.5	$1.50	$2,264 95
1896	71	205,043	4.45	21.5	23	1 112	2,280.07
1897	54	173,101	4.35	19.5	19	826	1,450 24
1898	47	148,30[illegible]	4.13	19 6	19.1	.829	1,230.01
1899	54	169,379	4.13	19 2	20.2	.834	1,457.67
1900	56	174,885	4.04	25	26	1 05	1,905 87
1901	73	189,691	4.26	22	23	.98	1,8[illegible]1.41
February.							
1894	......	......	......	......	......	......	......
1895	40	150,668	4.22	22 9	35.5	1.50	2,161 02
1896	76	230,731	4 23	19.3	22.5	.951	2,194.22
1897	54	174,909	4.28	20.2	19.7	.843	1,477.11
1898	51	153,874	4.12	19.4	18.9	.778	1,198.77
1899	55	159,116	4.04	21	22	.889	1,414.96
1900	57	157,905	4.06	24	25	1 015	1,661.53
1901	74	173,219	4.13	21.9	21.9	.904	1,658.29
March.							
1894	......	......	......	......	......	......	......
1895	44	177,319	4.05	18.7	28	1.118	2,072.98
1896	78	250,612	4.2	21.5	23	.97	2,430 45
1897	53	187,844	4.1	18.8	18.3	.75	1,479.87
1898	60	191,[illegible]44	4.04	18.7	18 2	.735	1,408.24
1899	47	168,084	4.2	20	20	.84	1,412 76
1900	53	171,452	4.1	24	24	.954	1,798 53
1901	79	191,188	4.09	21.9	21.9	.896	1,816.15
April.							
1894	14	53,146	4.0	20.3	2[illegible].5	.90	470 96
1895	47	190,154	3.76	19.6	18.1	.68	1,296.41
1896	81	214,119	4.10	16.5	14.5	.594	1,460 62
1897	48	1[illegible]0,581	4.0	17.4	16 9	.696	1,217 02
1898	50	198,094	3 96	18.4	17.9	.709	1,406 99
1899	47	171,676	4.08	19.	19.	.775	1,393.49
1900	51	167,711	4.07	19.3	19 3	.785	1,39[illegible].36
1901	79	212,250	4.04	20.3	20.3	.82	1,845.40
May.							
1894	31	135,171	4.0	16.5	22.5	.90	1,105.24
1895	51	221,832	3.9	17.2	15.7	.614	1,2[illegible]3.26
1896	84	298,597	4.02	15.7	14.2	.573	1,720.44
1897	51	240,614	4.02	14.3	13.8	.555	1,316.03
1898	51	242,106	3.93	15.8	15.3	.601	1,476.95
1899	51	217,303	4.12	17	17	.70	1,535.64
1900	59	216,059	4.11	19.5	19.5	.801	1,839.58
1901	90	317,197	4.10	18.5	18.5	.759	2,512.80
June.							
1894	35	156,426	4.0	17	15.5	.62	947.75
1895	53	193,820	3.86	17.7	16.2	.627	1,217.90
1896	69	278,423	4.06	15	13 5	.548	1,522.15
1897	52	263,452	3.91	14.5	14	.547	1,440.40
1898	55	238,557	3.90	15.9	15.4	.60	1,431.39
1899	52	215,158	4.07	18	18	.73	1,634.11
1900	62	237,501	4.03	18.8	18.8	.758	1,912.04
1901	89	334,140	4.04	18.7	18.7	.758	2,644.82

* Average market price of butter for the month according to Elgin quotations.

Milk supply of the University Creamery, April, 1894, to October, 1901 — Continued.

Month.	No. of patrons.	Milk.	Test of milk.	Elgin price.*	Paid the Patrons.		
					Per pound butter fat.	Per 100 lbs. milk (ave).	For milk.
July.							
1894	35	121,050	3.93	18.5	17	$ .668	$821 99
1895	51	150,653	3.98	17 5	16	.637	962.86
1896	67	216,985	4.04	14.7	13 25	.535	1,173.36
1897	53	232,991	4.01	14.5	14	.561	1,307.72
1898	56	190,910	4 00	16 5	16	.64	1,221.86
1899	51	172,934	4.09	18	18	.736	1,275.67
1900	61	199,740	4.01	19	19	.762	1,601.53
1901	97	253,747	4.00	19.4	19 4	.776	2,263.03
August.							
1894	36	102,783	3.98	23.5	22	.876	892.90
1895	51	13[illegible]	4 04	20 1	18 6	.751	1,019.01
1896	64	165,499	4 23	15.8	15.3	.647	1,0[illegible]9.40
1897	53	174,626	4.03	16 5	16	.645	1,109.91
1898	54	184,012	4.09	18 0	17.5	.716	1,316.87
1899	43	129,785	4.37	19 5	19.5	.852	1,058 65
1900	64	172,485	4.03	20	20	.806	1,457 9[illegible]
1901	97	226,904	4.08	20.5	20 5	.836	1,983.77
September.							
1894	33	89,197	4.18	24 2	22 7	.919	857.21
1895	51	124,470	4 08	21	19.5	.796	994 07
1896	57	153,28[illegible]	4.23	15.4	14.9	.622	964.87
1897	56	142,616	4.10	19.1	18.6	.785	1,073.18
1898	54	144,564	4.10	19.5	19	.779	1,131 50
1899	44	114,763	4.27	22	22	.939	1,079.62
1900	62	145,965	4.15	21	21	.871	1,3[illegible]9.81
1901	95	†164,895	4.23	20	20	.846	1,395.05
October.							
1894	38	109,246	4 41	22.8	21.3	.945	1,017.28
1895	51	112,573	4.26	22.	20 5	.873	979.26
1896	58	137,276	4.44	19.1	18.6	.818	1,134 26
1897	53	121,921	4.24	22.2	21.7	.927	1,119 15
1898	46	111,458	4.27	20.9	20.4	.871	968.90
1899	51	120,123	4.38	23 5	23.5	1.03	1,310 30
1900	58	113,409	4.42	21.5	21.5	.95	1,128.15
1901	95	203,691	4.44	22	22	.977	1,983.31
November.							
1894	38	83,870	4.44	24.5	23.	1.02	912 10
1895	62	122,821	4.35	22.2	20.7	.903	1,109 30
1896	55	109,805	4.46	20.5	20.	.892	990.92
1897	49	118,722	4.40	22.5	22.	.968	1,152.90
1898	43	104,379	4.33	22.	21.5	.931	969.19
1899	50	122,676	4.38	25.4	25.4	1.01	1,523.84
1900	54	99,850	4.22	25.2	25.2	1.063	1,122.63
1901	....	....	....	....	....	....	....
December.							
1894	45	128,126	4.32	23.4	21.9	.946	1,221.98
1895	67	159,013	4.39	25	23.5	1.031	1,641.38
1896	54	147,508	4.52	21.2	20.7	.945	1,390.08
1897	49	136,850	4 45	21.6	21.1	.939	1,288 00
1898	45	122,830	4.30	21.	22.	.946	1,152.17
1899	56	158,944	4.20	26.	27.	1.134	1,923.43
1900	64	164,924	4.24	24.5	25.5	1.081	1,828 20
1901	....	....	....	....	....	....	....

*Average market price of butter for the month according to Elgin quotations.

† For 25 days.

A summary statement of the milk supply for each of the past six years is given in the following table:

Year.	Ave. No. of patrons.	Milk, lbs.	Test of milk.	Butter fat, lbs.	Total amount paid for milk. Skim milk, hauling, etc.
1894*	32	986,896	4.04	39,584	$8,448.94
1895	51	1,890,400	4.08	76,892	17,332.40
1896	67	2,437,840	4.20	102,559	18,680.79
1897	55	2,152,693	4.12	88,744	16,030.60
1898	52	2,030,828	4.08	83,000	15,505.53
1899	50	1,919,886	4.20	82,000	17,890.44
1900	60	2,021,865	4.12	87,000	20,519.33

*For nine months only.

The monthly records show that about twice as much milk is received in May and June as in September and October. The warm weather, flies, and shortness of feed from drought in the early fall make a surprising reduction in the flow of milk in a very short time. On account of the higher prices paid for milk in the winter, many of our patrons arrange to have fresh cows in the winter months, and this partially accounts for our comparatively larger quantity of milk from January to March, than is received in the fall.

The average test of milk is highest in October and November when feed is short and many cows are near the end of their lactation periods. There is no perceptible change in the test during other months of the year, even though grain feeding in the winter and pasture feed in the spring increase the amount of milk produced by the cows.

The test of milk from year to year is comparatively uniform and a little higher than is reported in the dairy papers by some factories. This high test cannot be due to exceptionally good cows, as the results given in the following pages show our patrons' cows to be very ordinary animals.

Number of cows owned by patrons.—Most of our patrons keep only a few cows. Dairying is not a prominent feature on the farms from which we receive our milk, grain raising and

general farming being given more attention than the cows. We find it extremely difficult to get an accurate record of the number of cows each patron owns during a year. There are many changes in the herds, from sales or from additions to the herds. Some patrons sell milk to us only a part of the year and to retail milk dealers the rest of the time. These dealers also occasionally leave their surplus with us so that it is impossible to say each year that our milk supply is produced by an exact number of cows.

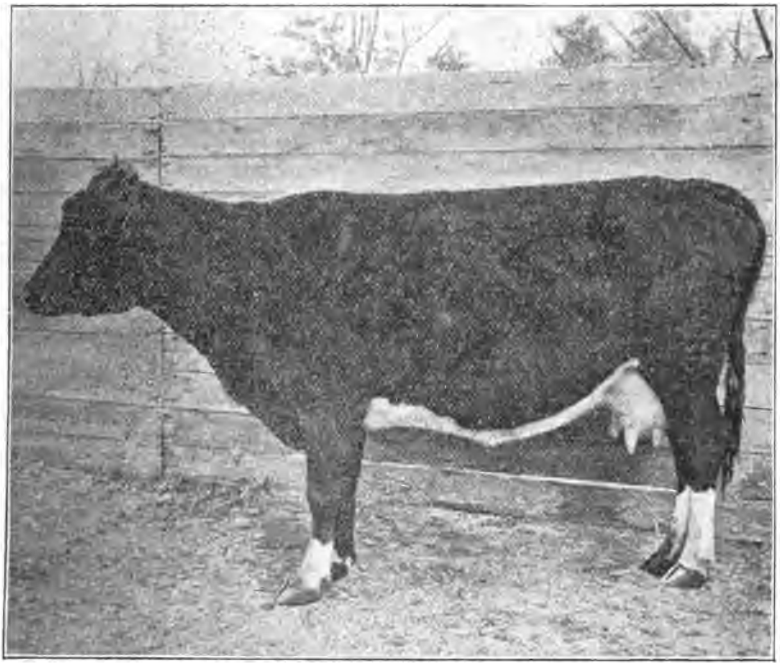

FIG. 18.—Cow No. 9. Tested three years. Produced 1st year, 171 lbs. butter; 2nd year, 136 lbs. butter; 3rd year, 182 lbs. butter.

The farms are visited each year by the writer. A cow census of our patrons taken during the present summer (1901) showed that there were 872 cows on 95 farms. Most of the herds are small in number, as shown by the following statement:

8 Patrons keep from 20 to 30 cows.
22 Patrons keep from 10 to 20 cows.
30 Patrons keep from 5 to 10 cows.
35 Patrons keep from 2 to 5 cows.

These cows are similar to those furnishing milk to the majority of the creameries and cheese factories in the state. Very few of them are pure-bred, and the feed and care the cows receive does not differ very much from that practiced by the average farmer.

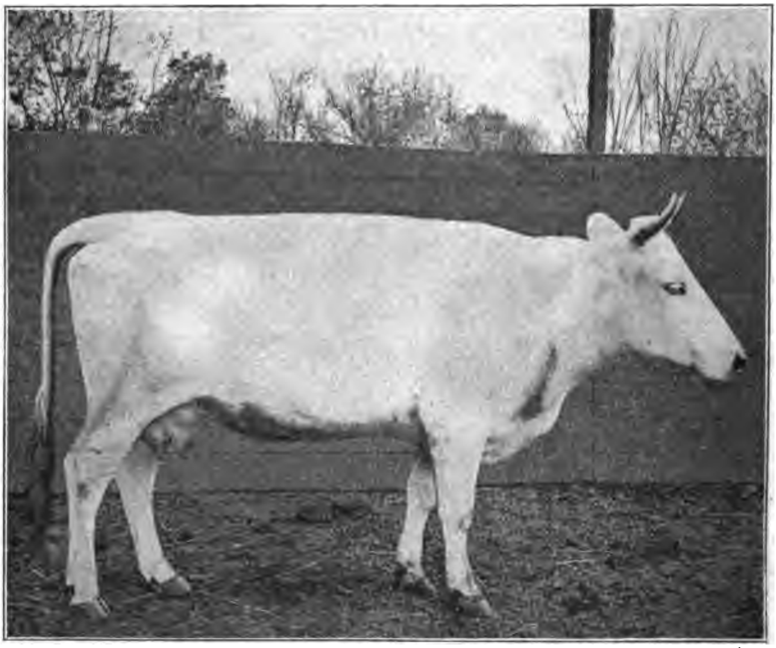

FIG. 19.—Cow No. 13. Tested three years. Produced 1st year, 240 lbs. butter; 2nd year, 256 lbs. butter; 3rd year, 229 lbs. butter.

Testing the cows.—Ever since the creamery was started we have urged our patrons to take samples from each cow's milk and allow us to test them, as this will aid in obtaining definite knowledge of the amount of milk and butter each cow produces. The patron's usual reply to these suggestions is that he "supposes it would be a good plan to test his cows," or he plainly states that "it is too much bother to take samples." He is either so much attached to his cows that he does not care to part with any of them even if it is proved that some cows do not produce milk enough in a year to pay for their feed, or he seems to think that he knows enough about his cows without having their milk tested. No one of our patrons during the past seven years has vol-

untarily brought samples of milk to us for any length of time with the request that we test them for him. This indifference to an exact knowledge of the profit or loss from cows is common among farmers, and on account of it they suffer annually very large financial losses. It is therefore plain that the possessor of such a disposition is as worthy a subject for investigation as are the cows he owns; the hope of convincing our patrons that cow records are valuable lead to a systematic testing of a number of herds in August, 1897, which investigation has been continued up to the present time.

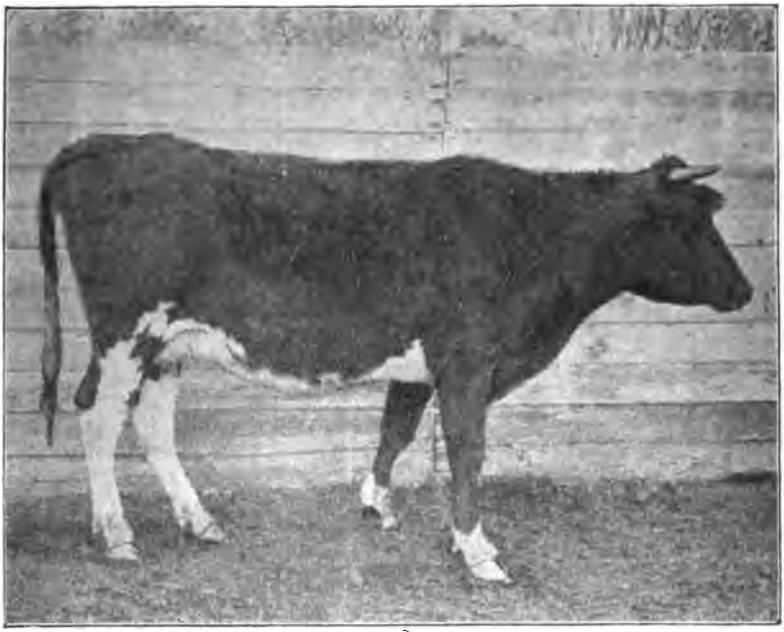

FIG. 20.—Cow No. 2. Produced in one year 191 lbs. butter worth $29.04.

In preparation for these tests we had boxes made for carrying four-ounce sample bottles of milk from the farms to our creamery. Small books in which might be recorded the weight of each cow's milk once a week, and accurate weighing scales were also provided. We offered this outfit to our patrons and agreed to test all samples they would send us if these were taken for one day at regular intervals of one, two or four weeks during the year.

Some patrons inquired how much we would pay them for the extra work of weighing each cow's milk once a week. This suggestion proved to be the only way in which we could get the work started, and we finally agreed to pay $1.00 per cow to such patrons as would weigh and sample the milk of each cow in their own herds at least once a month for one year. Even this inducement did not make much impression on the patrons, and we were able to test six herds only the first year, beginning August

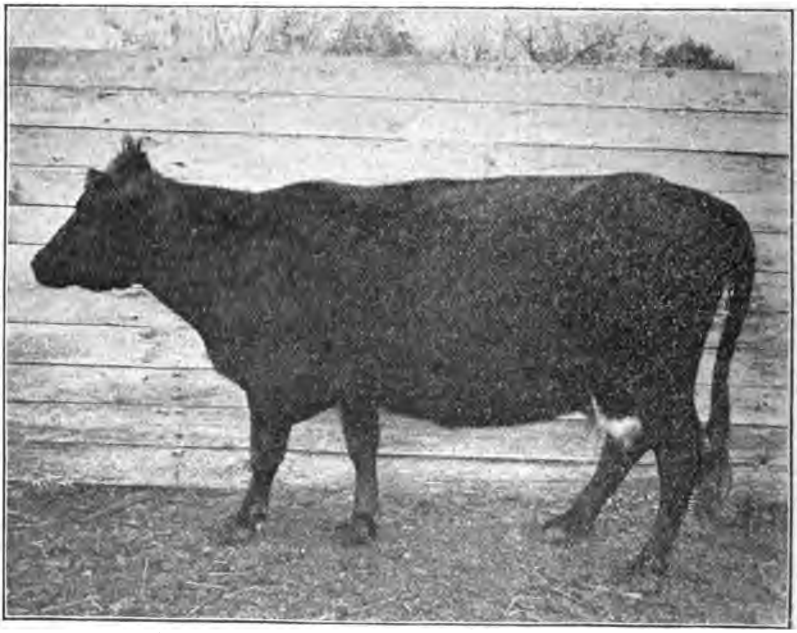

FIG. 21.—Cow No. 5. Tested three years. Produced 1st year, 280 lbs. butter; 2nd year, 301 lbs. butter; 3rd year, 221 lbs. butter.

1st, 1897. These tests included the weighing, sampling and testing of the milk of forty cows once every week through one complete period of lactation; eleven more cows were tested for a part of the year.

The results of this first year of testing were published in Bulletin 75 of this Station. Since that time the testing of patrons' herds has continued. During the year beginning April 1st, 1899, sixty-two cows on nine farms were tested through one complete period of lactation and fifty-four cows for only part of the

year. The following year fifty cows on six farms were tested, and up to the present time 217 cows on thirteen of our patrons' farms have been tested. These tests represent 135 complete and 98 partial periods of lactation. The cows in three herds were tested for three years consecutively and four other herds were tested for two consecutive years.

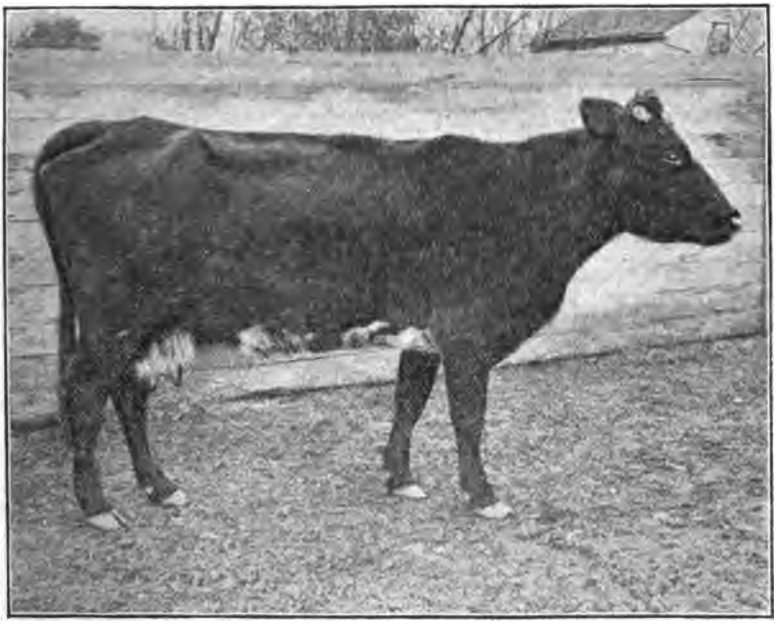

FIG. 22.—Cow No. 6. Tested three years. Produced 1st year, 205 lbs. butter; 2nd year, 181 lbs. butter; 3rd year, 252 lbs. butter.

During the first year of testing the milk of each cow was weighed and tested once each week, but it was impossible to get this done so often after the first year. Some patrons were willing to weigh and sample the milk of each cow once in two weeks and others could only be induced to do this "extra work" once a month.

The results obtained by this three years of testing have shown that farmers may gain a great deal of useful information by such work, and that it is one of the most profitable fields for careful observations in the whole domain of agriculture.

The following table gives a summary statement of the amount of cow testing done for our patrons between August 1, 1897, and April 1, 1901:

Cows tested for patrons during three years.

	AUGUST, 1897, TO AUGUST, 1898.				APRIL, 1899, TO APRIL, 1900.				APRIL, 1900, TO APRIL, 1901.			
		LACTATION PERIODS.				LACTATION PERIODS.				LACTATION PERIODS.		
Patron.	No. of cows.	Complete.	Partial.	How often tested.	No. of cows.	Complete.	Partial.	How often tested.	No. of cows.	Complete	Partial	How often tested.
A	12	11	1	Weekly	11	9	2	Every 2 weeks	11	9	2	Every month
B	7	5	2	Weekly								
C	12	12		Weekly								
D	6	4	2	Weekly	6	4	2	Every 2 weeks				
E	5	5		Weekly	5	5		Every 2 weeks	5	4	1	Every month
F	9	3	6	Weekly	7	6	1	Every 2 weeks				
G					14	11	3	Every 2 weeks				
H					8	6	2	Every 2 weeks	8	7	1	Every 2 w'ks
I					49	23	26	Every month				
J									7	4	3	Rvery 2 w'ks
K					8	6	2	Every 2 weeks	8	7	1	Every 2 w'ks
L					8		8	Every month				
M									11		11	Every month
Total	51	40	11		116	70	46		50	32	18	

A description of our methods of making the tests and some of the results obtained are given in the following pages:

Method of making the farm test.—The milk of each cow was weighed and sampled at the morning and night milking one day in each week, every two weeks or once a month as the patron desired. This testing day was selcted by the patron.

Each dairy was supplied with a pair of scales for weighing the milk, a box of bottles for milk samples, a small, 1-ounce tin sampling dipper and a record book. Each cow was given a number, which was also placed on the label of a 2-ounce sample bottle, the cow being known by this number throughout the test. About one-half gram of potassium bichromate was added to each sample bottle to keep the milk sweet until tested. The box of samples and the record book were sent to the University Creamery, where the samples were tested; the tests were recorded in the patrons' book as well as in the permanent record at the creamery, after which the book and box of sample bottles were returned to the farm.

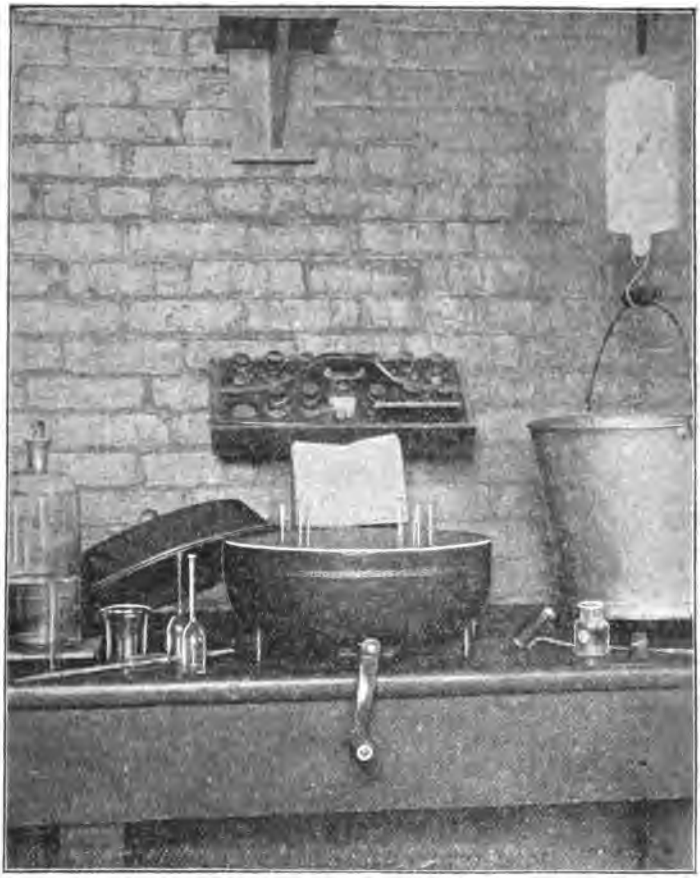

FIG. 23.—Babcock tester, milk scales and other supplies used in testing cows.

The following instructions were plainly written on the first few pages of the record book sent with each box of sample bottles:

DIRECTIONS.

1. Give each cow a permanent name or number.
2. Provide a place for using the scales at milking time.
3. Select a milk-weighing pail or bucket.
4. Record the weight of this empty pail or provide some sure way of deducting its weight from each lot of milk.
5. After milking a cow dry, pour all her milk into the weighing pail.
6. Record the weight of this milk in the proper place in the book.

7. Pour milk from weighing-pail into milking bucket and immediately dip a sample from it into a bottle having the number of this cow.

8. The sample from the first milking should only fill the bottle one-half full.

9. At the next milking repeat the weighing and sampling and pour the second sample into the same bottle that was previously half filled.

10. Each sample bottle should contain a mixture of the milk from two successive milkings of one cow.

11. Cork the sample bottles to prevent evaporation.

12. Weigh and sample the milk of each cow once, twice or four times per month.

13. Note time of each milking.

14. Record date each cow calves.

15. State how many days each calf was fed its mother's milk.

16. How did you dispose of each calf.

17. Weekly statement of cow's feed, including the weight, price and kind of grain, if any, with the amount and kind of hay, cornstalks or other coarse fodder.

18. Health of cows.

19. Note any change of milkers.

20. Record date when cow was dry.

The record books used were small, leather-covered, 4x6 inch books that ordinarily cost five cents. The books were ruled as shown below. Two opposite pages were taken for the record of the weights of milk of one cow. Other pages were reserved for recording the observations included in directions 15 to 20.

Method of arranging records.

Cow No. 1. Milk Record.							Age........ Fresh, Date........ Breed........ Sold calf, date........						
DATE.	Time of milking.		Night.	Morn	Total	Test.	Date.	Time of milking.		Night.	Morn	Total	Test.
	P. M.	A. M.	Lbs.	Lbs.	Lbs.			P. M.	A. M.	Lbs.	Lbs.	Lbs.	
....	.....	.....	....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....
....	.....	.....	....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....
....	.....	.....	....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....
....	.....	.....	....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....
....	.....	.....	....	.....	.....	.....	.....	.....	.....	....	.....	.....	.....

A great part of this testing and the necessary routine record work was done by Mr. Frank Dewhirst, who, with the writer

visited several farms at milking time twice during the year to obtain data in regard to the time required by the dairyman for weighing and sampling the milk and to note the accuracy of the work done.

One farmer, with twelve cows, estimated that fifteen minutes' extra time was required to weigh, sample and record the milk of his cows on testing days. At another place the records were taken by a boy who was too young to milk, but capable of doing the extra work required at milking time on testing day. At one farm this work was done by the women, who strongly objected to it, especially when it was necessary to use a lantern at the barn in winter.

Accuracy of the records.—The accuracy of such records as these is necessarilv influenced by conditions common to nearly all farms. Milking is usually done with more or less haste, especially at the planting, haying or harvesting seasons. The milkers as a rule are not accustomed to the use of scales and often consider a weight within one pound of the true figure to be "near enough." They do not understand the necessity of promptness in sampling milk after it has been poured from one pail to another before the cream has begun to separate. In spite of these and other disturbing factors, our results show that tests of dairy cows can be made by the farmers themselves with sufficient accuracy to give a very satisfactory knowledge of the performance of each cow.

In order to ascertain the accuracy of the data obtained by the method of testing described a one-day trial was made at four farms. A representative of the Dairy School visited the farms at both milkings in one day and saw the milk of each cow weighed and sampled.

The sum of these weights and the average tests were compared with the weights and tests of the milk delivered by each patron at the creamery that day. A summary of these results is given in the following table:

Comparison of farm and creamery weights and tests at four farms.

Farm.	No. of cows.	MILK OF ONE DAY.					
		Farm. Lbs.	Creamery. Lbs.	Difference.	Farm test.	Creamery test.	Difference.
A.....	8	130	115	15	4.56	4.5	.06
C.....	11	231	211	20	4.3	4.3	....
D.....	6	118	113	5	3.8	4.0	.2
E.....	4	79	73	6	4.5	4.4	.1

The milk was not tested at the creamery each day the cows were tested at the farm, but the weekly tests of the creamery composite samples may be compared with the farm tests for one day of each week. Such a comparison was made of the farm and creamery records of each patron for the entire year, and a summary of these results is given for one patron. It is to be expected that the farm weight should be greater than the creamery weight on any given day, because a certain amount of milk is always kept at home for family or other use. In some cases it will be noticed that the creamery weight was more than the farm weight. This must have been due to carelessness at the farm or to emptying the milk of some cow into the creamery cans without weighing it.

Comparison of the farm and creamery weights and tests from farm C for the entire year ending August 1898.

Date.		No. of Cows Milked.	Weight of Milk, Lbs.			Test of Milk.		Monthly Av. Test	
			Farm.	Cream-ery.	Farm excess.	Farm.	Cream-ery.*	Farm.	Cream-ery.
Aug.	1	12	234	231	3	4.5	4	4.3	4.05
	8	12	215.5	214	1.5	4.2	4.2		
	15	12	240	236	4	4.4	4.2		
	22	12	244.5	224	20.5	4	4		
Sept.	1	12	192	177	15	4.1	3.9	4.46	4.35
	5	11	183	171	12	4.4	4.3		
	12	10	169	162	7	4.4	4.4		
	19	10	139	139	0	4.9	4.2		
	26	10	162	150	12	4.6	4.6		
Oct.	3	8	151	126	25.5	4.7	4.5	4.88	4.75
	10	8	125	130	—5	4.7	4.4		
	17	9	111.5	109	2.5	5.2	4.9		
	24	9	90	96	—6	5.4	5		
	31	9	104	99	5	4.5	5		
Nov.	7	8	87	90	—3	4.9	4.9	5.05	4.8
	14	9	153	147	6	4.6	4.7		
	21	9	139.5	147	—8.5	5.2	4.8		
	28	8	130.5	123	7.5	5.4	4.8		
Dec.	5	8	137.5	145	—7.5	4.5	5	4.55	4.75
	13	9	163.5	161	2.5	4.6	4.8		
	20	9	166.5	161	5.5	4.3	4.7		
	26	9	203.5	188	15.5	4.7	4.5		
Jany.	3	9	200	195	5	4.7	4.3	4.46	4.3
	10	9	200	198	2	4.3	4.4		
	16	9	209	230	—21	4.1	4.4		
	23	9	234	235	—1	4.4	4.2		
	31	11	258.5	262	—4.5	4.6	4.3		
Feby.	6	12	247	240	7	4.3	4.4	4.3	4.2
	14	12	275	273	2	4	4.1		
	22	12	294	270	24	4.2	4.1		
	28	12	263	260	3	4.7	4.2		
March	3	12	272.5	273	0.0	4.4	4.2	4.4	4.05
	16	12	273.5	265	8.5	4.2	4.0		
	26	12	259.5	254	5.5	4.3	4.1		
April	2	12	249	242	7	4.5	4.2	4.5	4.1
	9	12	230	230	0.0	4.4	4.0		
	16	11	223	224	—1	4.6	4.1		
	23	11	221	214	7	4.4	4.4		
	30	11	207.5	203	4.5	4.4	4.3		
May	7	11	231	226	5	4.4	4.4	4.3	4.35
	14	11	232.5	228	4.5	4.1	4.4		
	21	11	229.5	220	9.5	4.4	4.3		
	28	11	205.5	210	—4.5	4.3	4.4		
June	6	11	213	198	15	4.4	4.3	4.3	4.2
	11	11	209	195	14	4.5	4.1		
	20	11	242.5	229	13.5	4.8	4.3		
	27	11	196	200	—4	4	4.2		
July	6	11	231.5	213	18.5	4.3	4.3	4.5	4.4
	12	11	198	190	8	4.7	4.4		
	20	11	158	142	16	4.6	4.4		
	28	11	153.5	140	13.5	4.5	4.6		

* Composite sample for the week.

A comparison of the annual records of twelve herds as obtained at the farm with the creamery record for the year is given below. The farm figures in this table, it should be remembered, are not found by weighing each cow's milk at every milking during her entire period of lactation, but are calculated from the weights taken each week, as described below:

Annual farm and creamery records.

FARM.	No. of cows milked.	WEIGHT OF MILK., LBS.			WEIGHT OF BUTTER FAT, LBS.			
		Farm.	Creamery.	Farm excess.	Farm.	Creamery.	Farm excess.	Tested at farm every
A-1898	12	57,813	56,053	1,760	2,355	2,270	85	Week.
A-1899 ...	11	48,293	45,108	3,185	2,022	1,884	138	Two w'ks.
A-1900	11	48,918	45,384	3,534	2,029	1,860	169	Month.
C-1898.	12	72,675	71,009	1,666	3,246	3,056	190	Week.
D-1898.....	6	34,558	31,290	3,268	1,422	1,275	147	Week.
E-1898	5	33,122	27,174	5,948	1,595	1,205	305	Week.
G-1899.....	14	64,692	61,639	3,053	2.915	2,672	243	Two w'ks.
H-1899	8	43,285	37,206	6,079	1,819	1,556	263	Two w'ks.
H-1900 . ..	8	41,316	37,215	4,101	2,022	1,741	281	Two w'ks.
J -1901.....	7	30,799	29,314	1,485	1,304	1,279	25	Two w'ks.
K-1900.....	8	33,603	32,917	686	1,385	1,343	42	Two w'ks.
K-1901.....	7	30,730	28,338	2,392	1,242	1,046	200	Two w'ks.

The difference between the farm and the creamery records includes the milk kept at home for family or other use and the inaccuracies in weighing and sampling the milk at the farm. In some cases this difference amounts to about the quantity of milk given by one cow for a year.

Each cow's record began after her calf was sold or when her milk was sent to the creamery. At farm E, the owner began testing each cow as soon as fresh, but fed the milk to the calf for about four weeks, until the calf was sold. This accounts for a part of the large difference between the farm and creamery records of this herd.

The total annual production of a cow is found by multiplying the average of the daily weights of milk and of butter fat taken each month by the number of days in the month, and adding the products together. The money value of the milk of each cow is found by multiplying the monthly weight of butter fat by a certain figure which, during the year ending Aug. 1, 1898, was one-half cent less than the average Elgin market price of butter for that month; in 1900 and 1901 it was the average Elgin

price* The figures obtained for each month are added together to find the annual value of the milk.

Monthly prices per pound of butter fat used in calculating the creamery value of the milk of each cow during the different years.

	1897.	1898.	1899.	1900.	1901.
January	....	19.1	....	26	23
February	....	18.9	....	25	21.9
March	....	18.25	....	24	21.9
April	....	17.9	19	22.5	20.3
May	....	15.3	17	19.5	....
June	....	15.4	18	18.8	....
July	....	16.0	18	19	....
August	16	....	19.5	20	....
September	18.6	....	22	21	....
October	21.75	....	23.5	21.5	....
November	22	....	25.4	25.2	....
December	21.1	....	27	25.5	....

Variations in the test of milk.—The tests of the milk of the same cows showed differences of one-half of one per cent., and occasionally even more than one per cent. on different days. These variations, however, tend to equalize each other from day to day, so that the average richness of the two lots comes near to the normal quality that the cow produces. This daily variation in milk is much more striking in some cows than in others, even when these receive the same feed and care; it seems to depend largely on the health and more or less excitable temperament of a cow, nervous cows showing a much greater tendency to unevenness in the quality of their milk than cows of a quiet disposition.

Feed and care of the herds.—The cows at each farm were fed and cared for during the entire year according to the usual practice of their owners. As far as we could ascertain, all the cows at one farm were fed in the same way. No attempt was made to vary the feed of each cow, excepting that where grain-feeding was practiced it was usually stopped while a cow was giving little or no milk.

At farm C the owner kept a careful record of all grain bought and fed to his cows during 1898. His estimate of this feed is given below:

*These are the prices which the creamery paid all its patrons for milk.

FARM C.—*Estimated feed cost and receipts from twelve cows.*

EXPENSES.		
* Grain bought during year		$180 00
30 acres corn stalks $2.00 per acre		60 00
10 tons clover hay $5.00		50 00
10 acres good pasture and 15 acres woodland		65 00
Total cost of feed		$355 00
RECEIPTS.		
Received for milk at creamery	$572 00	
Sold 12 calves at $5.50	66 00	
	$638 00	
60,000 lbs. skim milk 10 cts per 100 lbs	60 00	
Receipts exceed feed cost	....	343 00
	$698 00	$698 00

* The grain feed consists of corn and oats ground together, corn meal and bran, or about 15 tons of grain at $12 00 per ton.

This shows that the estimated cost of feed at farm C was nearly $30 per cow, and the average receipts per cow were a little over $58. Assuming that the manure will pay for the care of a cow, the owner of this herd received an average profit of $28 per cow.

Each cow on this farm was fed about the same amount of grain and hay during the period of stable feeding—November 1 to May 1. The grain was fed dry just before milking, 10 to 14 pounds per head being fed per day to cows in milk. Hay was fed the last thing at night after milking. During day time the cows were turned out into a sheltered yard, where they were fed cornstalks that had been stacked near the barn at husking time. The cornstalks were well eaten, and it is probable that the cows satisfied their differences in appetite on the cornstalks, if, as stated, each one was given the same amount of hay and grain. The cows had access to well water during the entire year, and were in pasture from May to November. When cows were fresh the calf was allowed to have its mother's milk for about three weeks, when it was sold for veal.

No exact feeding records could be obtained, except at farm C. at the other farms corn, bran or shorts, ground oats, pasture grass and a very little hay were fed in uncertain amounts, and apparently with no definite plan. At farm A no money was spent for feed during the year, but the corn and oats raised at home supplied all the grain the cows received, except that some oats were exchanged for bran to give the cows a variety of feed.

Although there was quite a contrast in the feeding and management at the different farms, the method of weighing and testing the milk of each cow was the same in each case. A summary of the results from each cow which was tested through one entire period of lactation is given in the following tables:

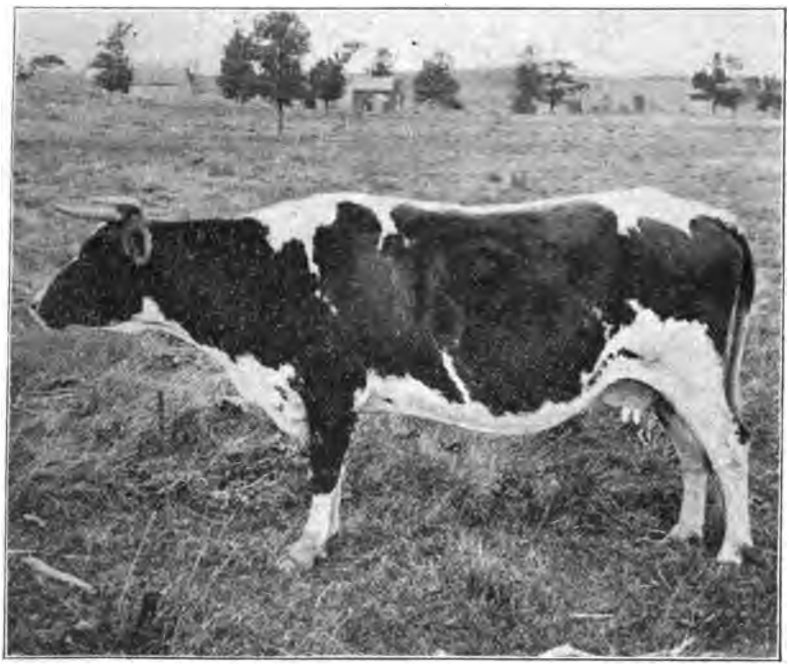

FIG. 24.—Cow No. 21. Produced in one year 286 lbs. butter worth $44.83.

FARM A. TWELVE COWS.

The cows on this farm have been tested for three years. The first year the weights and tests of each cow's milk were made every week, the second year once in two weeks and the third year once a month. Only six remained during the entire three years and their records are given first in the table, the best cow at the head of the list. The cows tested for two years are next given and, last, those tested during only one period of lactation. This herd suffered a great deal from abortion, especially in 1900.

FARM A.—*Annual production and creamery value of the milk of each cow tested through one or more periods of lactation during three years.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight Lbs. Milk.	Fat.	Days milked	Total Production, Lbs. Milk.	Test.	Fat.	Butter.	Creamery value of milk.
1	7	April, '97	20.4	.97	303	6,182	4.8	296	345	$53 35
1	9	March, '99	21.4	1.08	360	7,723	5.0	389	454	82 23
1	10	September, '00	19.2	.81	365	7,020	4.2	296	345	64 93
5	6	March, '97	22	.86	282	6,203	3.9	244	280	42 74
5	8	February, '99	24.1	.86	280	6,755	3.7	241	301	50 87
5	9	January, '00	15.4	.63	304	4,697	4.0	190	221	37 79
13	4	August, '97	18	.75	270	4,912	4.1	204	240	39 36
13	6	November, '98	19.6	.78	284	5,561	3.9	220	256	48 22
13	7	November, '00	19.1	.69	285	5,437	3.6	196	229	42 98
6	6	September, '97	13.9	.57	304	4,248	4.1	176	205	33 78
6	8	June, '99	16.3	.63	244	3,991	3.9	155	181	34 37
6	9	March, '00	18.9	.71	304	5,737	3.8	216	252	45 93
10	9	September, '97	20.1	.79	202	4,061	3.9	160	187	32 13
10	11	September, '99	13.4	.54	249	3,346	4.0	134	156	29 85
10	12	August, '00	11.7	.42	279	3,273	3.6	118	137	24 89
9	7	September, '97	13.9	.54	273	3,792	3.9	147	171	28 72
9	9	June, '99	14.6	.50	231	3,368	3.4	117	136	24 07
9	10	———, ——	14.4	.51	304	4,371	3.5	156	182	31 75
2a	4	January, '99	14.2	.69	279	3,971	4.8	193	225	40 98
2a	5	January, '00	10.7	.56	365	3,908	4.9	191	223	39 58
8	5	November, '97	20.1	.82	273	5,506	4.1	225	262	43 40
8	7	February, '99	17	.70	266	4,539	4.0	186	217	35 98
3a	2	December, '99	18.2	.74	108	1,972	4.0	80	93	20 18
3a	3	———, ——	10.5	.46	365	3,827	4.4	169	197	36 15
7	7	December, '97	16.3	.69	249	4,063	4.2	173	202	28 90
7	9	January, '00	15.8	.67	209	3,305	4.2	140	163	26 86
4a	......	March, '00	15.5	.78	306	4,759	5.0	239	278	49 26
12a	3	June, '99	12.2	.56	299	3,662	4.6	167	195	37 70
4	5	January, '97	17	.65	310	5,290	3.8	203	237	37 24
12	9	September, '98	22.1	.88	202	4,483	3.9	178	207	33 39
3	8	November, '97	14.8	.60	304	4,528	4.1	185	216	33 26
11	......	....	9.4	.44	334	3,151	4.8	148	172	31 37
2	10	March, '97	17.5	.62	262	4,546	3.6	164	191	29 04
8a	......	....	8.8	.35	311	2,738	4.1	110	128	23 51

The average receipts per cow in 1898, from the creamery, were $36.30; in 1900, $39.20, and in 1901, $38.92. In 1898 seven of the twelve cows produced less than the average of the herd; in 1900 seven of the eleven were below the average, and in 1901 there were six cows under the average production of the herd. The figures do not show much indication that the owner has profited by the tests. Two cows that did not produce enough milk to pay a profit on their feed were kept in the herd for three years, and five other cows produced less than $30.00 worth of butter in a year.

The average test of cow No. 6 was very uniform for the three years, while that of No. 1 and No. 9 varied .8% and .5%, respectively in the three years. The number of days in a year that the

cows gave milk varied with the different cows, some of them, like No. 13, were milked very nearly the same length of time each of the three years, while with others there was a difference of over sixty days in the length of the periods of lactation of the same cow. In this particular herd there was so much abortion that the periods of lactation were not always normal.

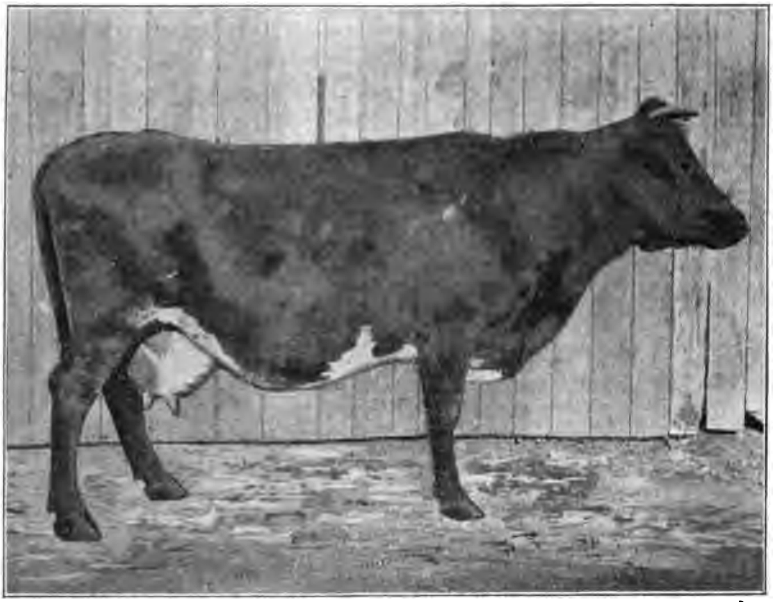

FIG. 25.—Cow No. 37. Produced in one year 392 lbs. of butter worth $60.72.

The annual production of the mature cows during the three years shows that the poor cows did not improve from year to year, but continued to give less milk than required to pay for the feed consumed. This is shown by the records of No. 9 and No. 10. The one good cow was equally persistent in doing well. The creamery value of her milk for three years was $200.00. This is $110.00 more than the cost of her feed when we take $30 per year as the value of a cow's feed. The butter produced by the other five cows tested for three years amounted to only $114.00 more than the cost of their feed during the same time. The milk of one cow, therefore, paid the owner within four dollars as much profit in three years as the milk of five cows in the same herd for the same length of time.

FARM B.—*Five cows tested each week, during the year ending August, 1898. The milk was sold on a milk peddling route.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight Lbs.		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
25	6	July, '97	21.6	.85	365	7,887	3.95	312	364	$58 21
23	4	May, '97	24.5	1.00	274	6,718	4.3	279	325	49 55
24	4	July, '97	18.3	.87	304	5,583	4.75	265	309	49 53
22	4	April, '97	16.4	.84	316	5,193	5.15	267	311	47 89
21	6	June, '97	20.2	.76	322	6,534	3.75	245	286	44 83

FARM C.—*Twelve cows tested each week during the year ending August 1st, 1898.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight		Days milked.	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter	
37	10	April, '97	19.7	1.06	344	6,779	4.9	336	392	$60 72
32	11	October, '97	26.7	1.06	304	8,132	4	324	378	59 81
34	8	June, '97	21.8	.88	350	7,654	4	309	360	57 56
42	4	March, '97	18.5	.94	334	6,200	5	315	367	55 45
31	6	April, '97	15	.81	344	5,161	5.4	282	329	50 00
41	12	December, '97	18.8	.84	311	5,870	4.6	264	308	49 76
40	7	December, '97	21.9	.91	278	6,109	4.1	256	298	44 71
33	7	April, '97	16.5	.74	304	5,018	4.5	227	264	43 52
39	10	December, '97	22.5	.85	291	6,561	3.8	248	289	42 52
36	9	February, '97	17.1	.76	312	5,340	4.5	240	280	42 45
35	10	June, '97	14.6	.73	302	4,411	5.5	222	259	41 96
38	8	February, '97	21.8	.89	249	5,440	4.1	223	260	37 96

The cows of this herd were fed much more grain than is customary in this locality (see page 116), but even under heavy grain feeding conditions it pays well to test the cows, as is shown by comparing the record of the first two cows in the table with those of the last five cows. The excess of the two cows of butter over cost of feed was worth $60, while that of the five cows was worth only $58. Thus the owner received at the creamery $2.00 less for the milk of five cows than he did for that of two cows in the same herd.

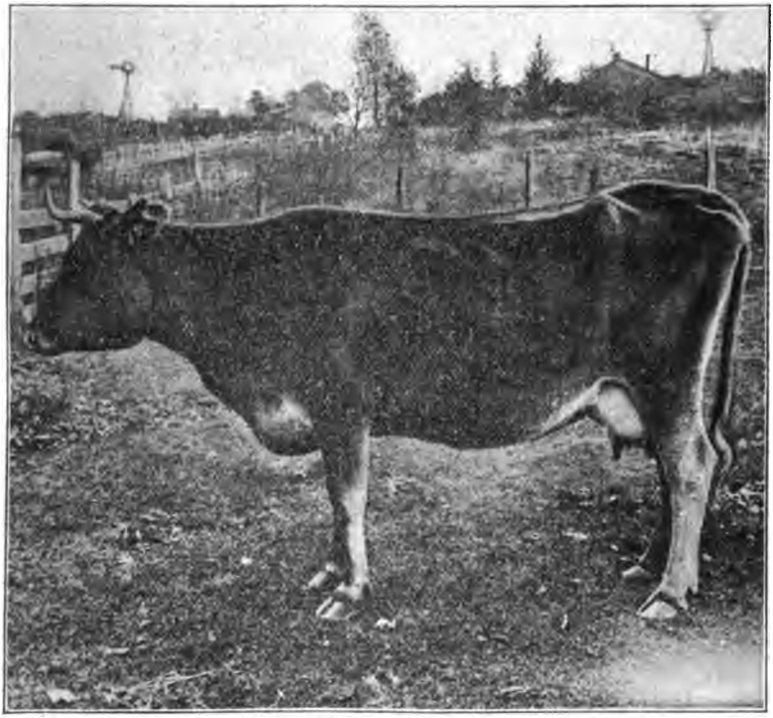

FIG. 26.—Cow No. 52. Produced in one year 286 lbs. butter worth $40.37.

FARM D.—*Eight cows tested each week through one period of lactation during the year ending August 1st, 1898, and once in two weeks during the year ending April 1st, 1900.*

Cow No.	Age, yrs.	Fresh.	Ave Daily Weight of Milk.	Ave Daily Weight of Fat.	Days milked	Total Production, Lbs. Milk.	Test.	Fat	Butter.	Creamery value of milk.
55	9	September, '97 ...	20.6	.94	318	6,570	4.5	300	350	$55 49
52a	5	May, '99	21.8	.85	291	6,366	4	250	291	51 28
53	9	April, '99	18.8	.74	325	6,136	4	243	283	50 85
56a	3	May, '99	15	.72	295	4,452	4.9	217	253	47 15
51	9	May, '97	18.5	.78	295	5,462	4.3	235	274	41 40
52	7	March, '97	18.7	.73	334	6,274	3.95	245	286	40 37
56	8	January, '97	15.1	.69	321	4,847	4.3	223	260	39 60
55a	10	November, '98 ...	7.4	.35	365	2,711	4.7	128	149	28 40

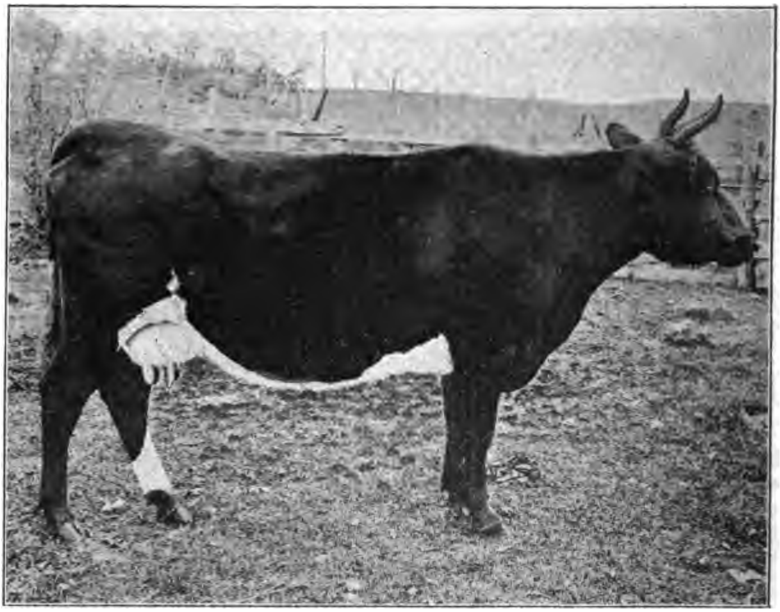

FIG. 27.—Cow No. 55a. Produced in one year 149 lbs. butter worth $28.40.

FARM E.—*Record of four cows tested three years and one cow tested for two years; weights and tests of each cow's milk were made each week the first year, once in two weeks the second year and once a month the third year.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight of		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk	Fat.		Milk.	Test.	Fat.	Butter.	
62	4	October, '97	27.2	1.11	288	7,854	4.2	320	373	$60 69
62	6	September, '98 ...	24.2	.98	290	7,023	4	285	333	68 16
62	7	October, '00	27.1	1.03	305	8,288	4	316	369	70.72
61	8	June, '97	21	1.12	325	6,938	5.2	365	426	67 47
61	10	March, '99	18.7	.93	306	5,730	5	285	333	61 22
61	11	....	19.3	.89	310	6,013	4.6	277	323	59 47
63	3	October, '97	17.2	.97	242	4,169	5.7	236	275	44 40
63	5	September, '98 ...	14.9	.86	334	4,985	5.7	288	336	66 44
63	6	August, '00	16.5	.91	310	5,114	5.6	285	333	62 30
65	5	March, '97	25.2	1.2	317	8,000	4.8	381	444	64 87
65	7	April, '99	23.5	1.03	302	7,117	4.4	312	364	66 35
65	8	March, '00	22.7	.94	300	6,832	4.1	283	330	60 27
64	9	November, '97	20.7	1.0	297	6,161	4.9	300	350	54 65
64	11	October, '98	13.2	.63	312	4,143	4.8	198	231	43 79

The points of special interest in the three years' record of this herd are, first, its uniform excellence as to annual production. Second, a comparison of the records and the pictures of the dif-

ferent cows. From the general appearance and form of cow No. 64 some persons would consider her a much better dairy cow than No. 65, but the records obtained with the Babcock test show that the creamery value of the milk of No. 65 for two years amounted to $32.78 more than that from cow No. 64 during the same time. Third, the fact that the cows were all fed and cared for by the owner. This fact, it seems to me, is one cause of the cows doing so well. Hired help and indifferent milkers are often the cause of poor records for dairy cows.

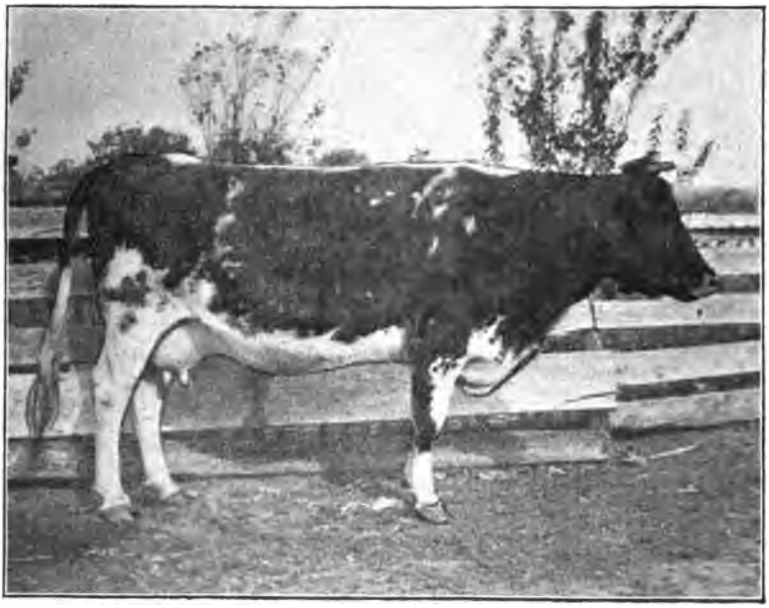

FIG. 28.—Cow No. 61.—Tested three years. Produced 1st year, 426 lbs. butter; 2nd year, 333 lbs. butter; 3rd year, 323 lbs. butter.

FARM F.—*Nine cows tested through one period of lactation during the year ending August 1st, 1898 and April 1st, 1900.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight of		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
75	6	September, '97 ...	25.2	1.12	286	7,221	4.5	325	379	$60 29
71	10	November, '98	19.1	.82	319	6,114	4.3	262	305	58 70
76	2	March, '99	12.6	.62	331	4,167	4.9	205	239	44 30
75a	2	March, '99	14	.61	324	4,506	4.4	200	233	43 79
74	5	January, '99	12.7	.60	328	4,179	4.9	200	233	43 69
72	3	March, '97	17	.77	306	5,205	4.5	237	276	41 84
73a	5	February, '99	14.3	.62	294	4,219	4.4	184	215	40 83
73	3	March, '97	14.1	.66	306	4,320	4.7	203	237	33 99
77	2	April, '99	8.7	.41	365	3,272	4.9	155	171	31 90

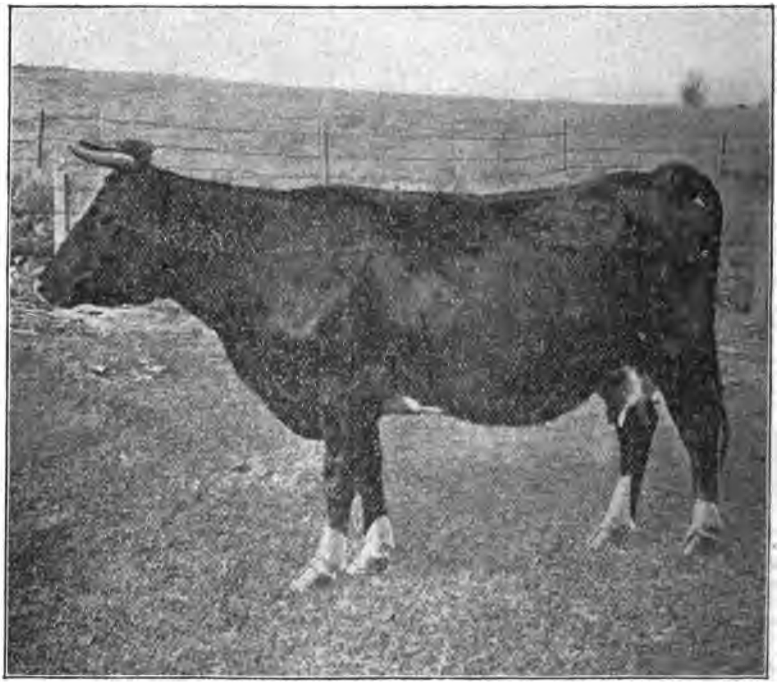

FIG. 29.—Cow No. 63. Tested three years. Produced 1st year, 275 lbs. butter; 2nd year, 336 lbs. butter; 3rd year, 333 lbs. butter.

FARM G.—*Eleven cows tested once in two weeks, during the year ending April 1st, 1900.*

Cow No.	Age, yrs.	Fresh.	AVE. DAILY WEIGHT OF		Days milked	TOTAL PRODUCTION, LBS.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
92	3	March, '99	24.1	1.03	347	8,480	4.2	360	420	$72 21
91	3	March, '99	20.9	1.05	319	6,674	5.	335	391	70 44
93	3	March, '99	17.5	.93	316	5,547	5.3	294	343	62 78
90	3	March, '99	19.1	.90	324	6,197	4.7	293	342	61 27
85	7	November, '98	18.7	.79	321	6,217	4.2	262	305	56 68
94	3	April, '99	18.7	.91	292	5,462	4.9	266	310	56 50
84	7	November, '98 ...	18.9	.77	312	5,916	4.1	242	282	52 26
81	7	November, '98 ...	18.3	.82	299	5,478	4.5	246	286	51 27
82	5	November, '98 ...	17.3	.77	284	4,920	4.4	219	259	46 15
86	5	January, '99	17.8	.68	304	5,426	4.	207	241	43 39
89	5	October, '98	16.2	.71	270	4,375	4.4	191	223	39 32

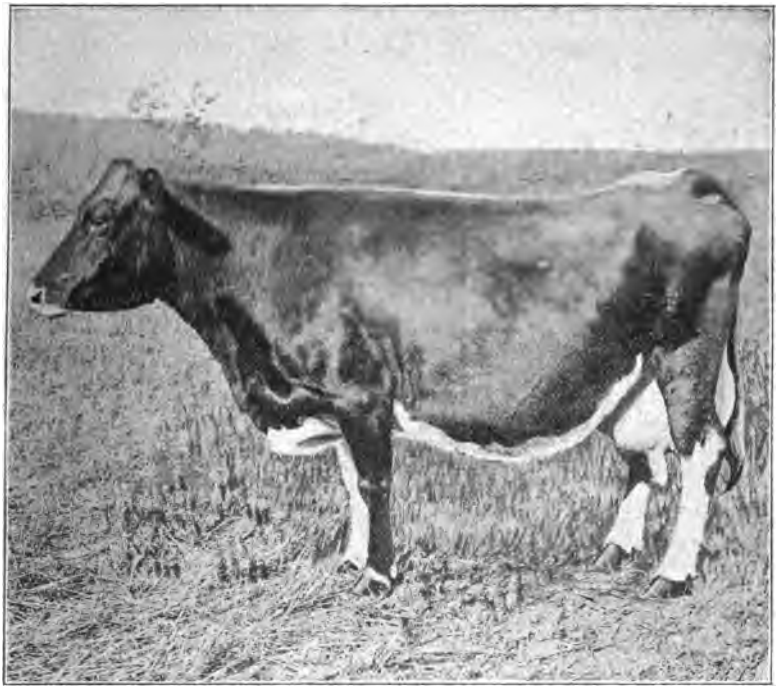

FIG. 30.—Cow No. 64. Tested two years. Produced 1st year, 350 lbs. butter; 2nd year, 231 lbs. butter.

FARM H.—*Eight cows tested once in two weeks during two years ending April, 1901.*

Cow No.	Age, yrs.	Fresh.	AVE. DAILY WEIGHT OF		Days milked	TOTAL PRODUCTION, LBS.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
102	6	September, '98 ...	22.5	.92	314	7,084	4.1	290	338	$66 08
102	7	September, '00 ...	18.3	.72	341	6,260	4.	247	281	62 41
103	6	February, '99	24.7	1.	281	6,950	4.	280	327	59 51
103	7	February, '00	20.4	.89	328	6,707	4.3	291	339	62 71
106	7	December, '98	23.6	.98	241	5,750	4.1	236	275	56 92
106	8	October, '00	21.3	.89	296	6,265	4.2	265	309	58 34
105	2	December, '98	19.4	.83	289	5,598	4.	239	279	54 37
105	3	October, '00	20.5	.82	259	5,326	4.	214	250	50 84
101	3	March, '98	15.3	.74	284	4,353	4.8	210	245	49 25
101	4	November, '00	15.6	.75	327	5,110	4.8	245	306	52 79
108	5	December, '99	32.6	1.23	147	4,796	3.8	181	211	45.57
108	5	December, '00	21.5	.93	302	6,490	4.3	281	324	59 21
104	......	October, '00	16.2	.64	256	4,164	4.	165	192	46 65
107	2	September, '99	12.9	.40	147	1,896	3.8	71	83	17 23

Farm I.—Forty-nine cows were tested on this farm, but complete records were only obtained from 24 cows for one lactation period. The cows were tested once in thirty days, between March, 1900, and June, 1901. The records of the cows are given in the table in the order of the creamery value of their milk:

FARM I.

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight of		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
134	5	December, '00	22.4	.92	343	7,673	4.1	316	369	$67 85
111	11	October, '99	19.9	.77	334	6,756	3.9	266	310	58 98
148	8	February, '00	21.5	.89	287	6,173	4.	257	300	51 97
129	11	December, '99	18.7	.84	290	5,431	4.5	245	286	50 00
133	6	June, '00	21.	.78	293	6,147	3.7	230	268	48 76
142	......	....	18.7	.72	306	6,093	3.7	223	260	47 25
112	8	June, '00	21.7	.74	304	6,371	3.5	225	262	47 20
149	8	August, '00	16.5	.69	300	4,905	4.	207	242	45 28
143	4	April, '00	15.2	.61	335	5,203	3.9	203	237	44 52
119	8	May, '00	16.5	.66	304	4,986	4.	205	239	43 37
115	5	May, '00	18.2	.7	325	6,086	3.4	207	242	42 74
114	10	June, '00	22.	.72	274	5,961	3.2	192	226	42 11
141	4	March, '00	17.1	.72	278	4,766	4.2	201	234	40 67
117	12	July, '00	16.9	.5	345	6,456	3.	189	220	40 27
121	9	July, '00	16.2	.56	294	5,025	3.5	175	204	40 11
123	8	June, '00	14.4	.58	274	4,073	4.1	164	191	35 34
118	5	May, '00	13.7	.61	260	3,478	4.4	155	181	32 91
138	6	July, '00	10.8	.51	273	2,940	4.7	139	162	32 04
116	12	July, '00	14.5	.55	254	3,653	3.9	141	164	30.98
122	9	June, '00	10.2	.39	283	3,107	3.8	119	139	25 22
135	2	September, '00 ...	13.6	.53	200	2,738	3.9	106	124	24 64
126	12	July, '00	10.6	.39	213	2,254	3.7	83	97	18 67
131	2	September, '00 ...	10.3	.38	212	2,182	3.7	81	94	18 44
130	3	June, '00	6.4	.32	215	1,380	5.	69	80	14 56

FARM J.—*Four cows tested once a month during the year ending May 1st, 1901.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight of		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
154	3	October, '99	18.7	.79	311	5,820	4.2	245	286	$51 14
151	8	January, '00	20.3	.77	308	6,265	3.8	237	276	48 61
156	3	March, '00	16.2	.72	319	5,210	4.4	230	268	47 71
152	6	September, '99 ...	16.6	.58	291	4,840	4.1	170	198	37 57

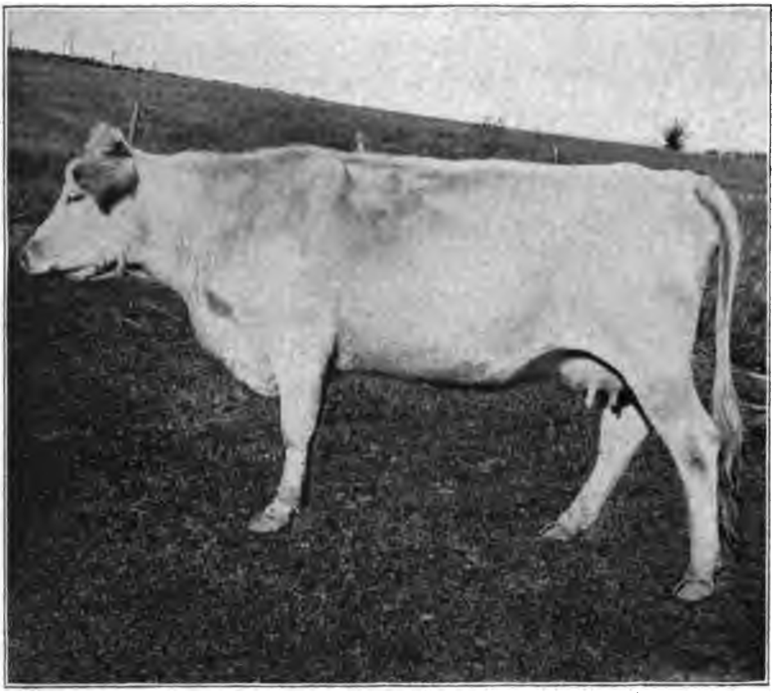

FIG. 31.—Cow No. 65. Tested three years. Produced 1st year, 444 lbs. butter; 2nd year, 364 lbs. butter; 3rd year, 330 lbs. butter.

FARM K.—*Four cows tested once in two weeks during two years ending May 1st, 1901, and three cows tested for one year.*

Cow No.	Age, yrs.	Fresh.	Ave. Daily Weight of		Days milked	Total Production, Lbs.				Creamery value of milk.
			Milk.	Fat.		Milk.	Test.	Fat.	Butter.	
164	......	October, '99	16.5	.68	365	6,040	4.1	247	308	$54 61
164	......	November, '00	17.1	.70	289	4,945	4.	203	237	45 47
161	9	April, '99	19.9	.74	314	6,865	3.6	232	270	48 26
161	10	May, '00	18.1	.64	348	6,319	3.5	223	260	46 81
166	2	January, '99	10.9	.48	239	2,603	4.3	114	133	22 35
166	3	April, '01	17.7	......	276	4,883	4.1	196	229	40 96
167	2	April, '99	10.9	.56	267	2,912	5.	150	178	32 68
167	3	May, '01	12.1	.57	291	3,535	4.8	166	194	36 69
163	5	November, '99	16.9	.68	234	4,120	4.1	165	193	38 88
162	11	August, '99	14.7	.51	342	5,062	3.5	174	203	38 65
168	3	May, '99	10.4	.50	331	3,449	4.8	165	192	36 65

The figures given furnish evidence on many questions on which the great majority of creamery and cheese factory patrons have more or less positive opinions. Probably very few farmers realize that there is so great a difference in the production of the different cows in a herd as is shown by these records, but the

records are undoubtedly a fair representation of the 1,000,000 cows that produce the butter and cheese of this state. As already explained these cows were all measured by the same standard, the weight and test of their milk for a year. About $10 should be added to the factory value of the milk of each cow as given in the table. This represents about the average value of the skim milk, 5,000 pounds at 10 cents per 100 pounds, and a veal calf three weeks old.

The extreme variation in the butter value of the cows on the different farms is shown in the following tabl :

Table showing variations during one year in the butter value of the cows in each herd.

Patron.	No. of cows in herd.	Creamery Paid.		Creamery Value of		
		Total cash.	Average per cow.	Best cow.	Poorest cow.	Average cow.
A—1898	12	$421	$35 11	$53 35	$28 72	$36 30
A—1900	11	405	36 82	82 23	20 18	39 20
A—1901	11	424	38 55	64 93	23 51	38 92
B—1898	5	*..........	....	58 21	44 83	50 00
C—1898	12	572	47 70	60 72	37 96	48 83
D—1898	6	228	38 00	55 49	39 60	44 12
D—1900	6	....	....	51 28	28 40	44 42
E—1898	5	227	45 40	67 47	44 40	58 40
E—1900	5	....	....	68 16	43 47	61 20
E—1901	4	....	....	70 72	59 47	62 11
F—1898	9	....	....	60 29	34 00	....
F—1900	7	....	....	58 70	31 90	44 00
G—1900	14	563	40 00	72 21	39 32	56 57
H—1900	8	358	44 75	66 08	17 23	50 00
H—1901	8	332	41 50	62 71	46 65	56 00
I—1901	24	....	....	67 85	14 56	39 00
J—1901	7	270	38 60	51 14	37 58	46 00
K—1900	8	293	37 00	54 61	22 35	39 00
K—1901	8	248	31 00	46 81	36 69	42 00

*Figures are not obtained because patrons did not bring milk to the creamery during the entire year; samples of each cow's milk were, however, tested.

If, as stated, each farmer fed all his cows in the same way, and the time and labor of milking and feeding the cows was approximately the same for both good and poor cows, it follows that it did not cost any more to feed the best than the poorest cows in herd. The information furnished by such tests as these may be very valuable to the owner of the cows, and it should be of vital importance to the cow, as her life ought to depend on the record she makes. Previous to making the tests the owners of these cows had very little, if any, accurate idea of the relative value of their cows, but the records show that the information gained is worth many times the cost of a milk scale and Babcock milk test, and the time necessary to use them.

THE TROWBRIDGE METHOD OF CALIBRATING BABCOCK TEST BOTTLES.

E. H. FARRINGTON.

Since the Babcock milk test became generally adopted, a great deal has been said and written in regard to the necessity of having the test bottles correctly graduated. The accuracy of the graduations is considered to be of so much importance in some states that laws have been passed and inspectors appointed to examine the pipettes, the acid measures and especially the test bottles in order to make sure that properly calibrated glassware is in use.

The methods of testing the graduations of the whole milk test bottles have, in the past, required such careful and delicate manipulations that not every one who uses a Babcock test feels capable of undertaking an examination of the bottles to see if they are correctly made. The space between the 0 and the 10 per cent. marks of the scale on the necks of the bottles should be exactly two cubic centimeters and a weighed quantity of mercury, or a pipette that will deliver exactly 2 cubic centimeters, have been the standards used in examining the test bottles.

A much simpler way of inspecting the graduations of milk test bottles has been proposed by Mr. O. A. Trowbridge, a creamery butter maker of Columbus, Wisconsin. He conceived the idea of measuring the capacity of the scale on a milk test bottle by means of a thirty-penny iron nail which he carefully filed until it was just large enough to displace 2 c. c. of liquid. A piece of fine copper wire served as a handle for lowering this into the neck of a test bottle previously filled with water to the zero mark. If the graduated scale of the bottle is correct the water will rise exactly to the 10 per cent. mark when the iron measure is entirely submerged in the water.

The principle of this method is an entirely correct one and the idea is a valuable contribution to the Babcock test apparatus. One of the standard measures was sent to me by Mr. Trowbridge, and several comparisons have been made with it and the other methods previously used for calibrating test bottles. The comparisons showed the Trowbridge method to be one that can be used by all persons capable of testing milk; one of these standard measures should be included in the outfit accompanying each Babcock milk test.

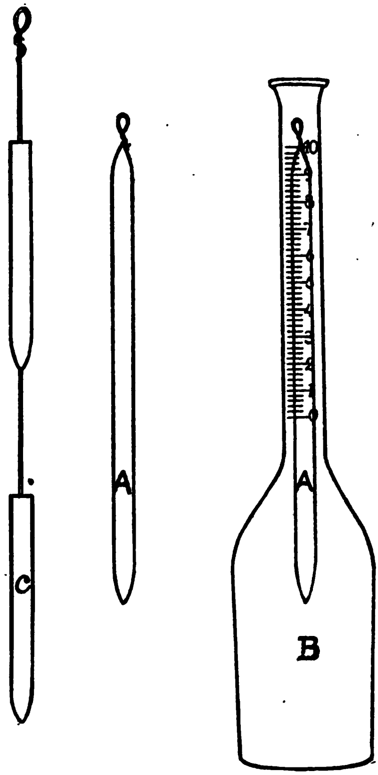

FIG. 32.—Shows the original Trowbridge tester (A), its method of use in a test bottle (B), and the Nafis modification (C).

It is necessary to have the inside surface of the neck of a test bottle absolutely clean and dry before it is calibrated. A film of grease interferes with the forming of a meniscus and renders an exact reading very difficult. The test bottle must be thoroughly cleansed and the inside of the neck wiped dry with a clean dry cloth. The bottle is then filled with water to the zero

mark of the scale and the perfectly dry standard measure lowered into the water until the upper end of the measure is just below the 10 mark of the bottle. If the water rises exactly to this 10 mark, the 10 mark is accurately placed; but any variation in the height of the water above or below the 10 mark shows incorrect graduations.

When lowering the measure into the test bottle the operator should make sure that no air bubbles are left in the neck below the surface of the water or adhering to the measure; water should not be forced above the 10 mark on the neck during the calibration as the thin film adhering to the surface of the glass may be sufficient to affect the reading. If these precautions are observed in using this calibrator it will be found a very satisfactory piece of apparatus. About the only objection which can be raised to it will be caused by a dirty or greasy surface of the neck of the test bottle. This difficulty can be so easily overcome that it seems hardly worth mentioning.

A slight modification of the original Trowbridge idea has been made by the instrument makers, Louis Nafis Co., of Chicago. They have placed on the market an instrument which will test the 5 per cent. mark of the scale as well as the 10 mark. We have used two of these and found them to be very satisfactory.

PRINT CHEESE.

E. H. FARRINGTON.

Manufacturers and dealers in food products of all kinds are more or less familiar with the advantages to be gained from a neat package and an attractive appearance of the articles offered for sale. Style and finish are important factors in trade and in making a selection the consumer is influenced by the appearance as well as by the quality of the product. This is well understood by progressive manufacturers and dealers in dairy products, and the necessity of careful attention to these details is continually being urged upon every one connected with the dairy industry. More consideration in this direction seems in the past to have been given to butter than to cheese, and excepting some high-priced small packages and jars, the bulk of the cheese is still made in large sizes which are cut into awkward slices and sold by the pound at groceries.

One of the most popular butter packages is the one-pound print. In some markets print butter is quoted at one cent or more above the ruling price of other butter, which may be of the same quality but is put up in a less attractive package. This popularity of print butter shows that it is profitable to study the market demands regarding the shape and the appearance of dairy products as well as their flavor, texture and other qualities.

On account of the demand for print butter the manufacturers and dealers in dairy supplies have designed a number of machines and appliances for economically molding the butter into print forms. These machines vary somewhat in their construction and manipulation, but they all make the one-pound print of about the same dimensions, $2\frac{1}{2}$ x $2\frac{1}{2}$ x $4\frac{1}{2}$ inches. In some

printers a carved board is placed on one side of the mold into which the butter is pressed and this makes an impression in each print of some design or letter which has been selected as a brand or trade mark by the manufacturer. So much attention has been given to the subject of butter printing that the details of its manufacture are now satisfactorily worked out.

The favorable reputation which print butter has attained suggested to the writer the possibility of applying the idea to the manufacture of cheese. Why cannot cheese as well as butter be molded into one-pound prints? After studying this question for two years we are prepared to say that this new form of cheese can be made and that it is received with much favor by the consumer. Our first print cheese was made during the winter of 1898–99. Since that time some of the details in its manipulation have been changed but the general plan of the operation is the same as originally carried out. In so far as the cheese is concerned we have made no deviation from the usual process of cheddar cheese making but have modified the pressing and the "follower" used in the press.

Method of making print cheese adopted.—The Cheddar cheese curd is placed in a mold or hoop of rectangular shape, the bottom or "follower" of which is a carved board. This board makes the impression of the raised letters U. W. (University of Wisconsin) and the grooves which mark the cheese into prints, as shown in the Fig. 33. Each section on which the U. W. is stamped represents one-half pound of cheese, two sections making one pound. This one pound print of cheese is about the size of a one-pound print of butter. Its length and width are determined by the carving of the board which may be made of any size or design to suit a particular trade; the thickness of the block is of course regulated by the amount of curd put into the mold each time. The cheese shown in Fig. 33 weigh between fifteen and sixteen pounds each and will cut into fifteen one-pound prints. The dimensions of each block of fifteen prints are 11½ x 13¼ x 2½ inches thick. Each print is 2½ x 2½ x 4¼ inches in size.

Our cheese have been pressed in an upright press, the carved board placed at the bottom of the rectangular mold and the band-

age cloth cut to cover the carved board, sides and bottom of the cheese. The ends of the bandage cloth come together on the smooth side of the cheese and the cloth is cut so as to make smooth, neat corners.

A metal hoop similar to the cheddar cheese hoops with fasteners, etc., can doubtless be made for this kind of cheese so that they may be used in horizontal gang presses and a number of them put to press at the same time. By carving both sides of the board it can be used for molding two cheese when the board is placed in the press between the cheese.

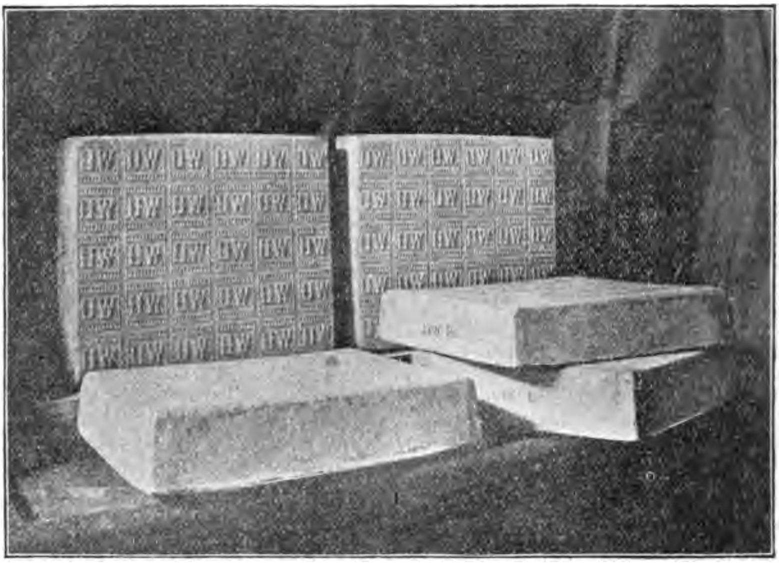

FIG. 33.—Cheddar cheese made for cutting into one-pound prints.

We have no difficulty in curing these cheese in the same way as cheddar cheese is cured. The bottom and sides should be greased and the cheese turned occasionally, although it should not rest on the carved surface for a very long time. By exercising a little care in handling these cheese during the curing process they can be kept clean and attractive in appearance, and if well made from good milk will develop an acceptable flavor that together with the trade mark branded into each pound will be helpful in protecting the reputation of cheese from a certain

factory. Our print cheese have been cured in our regular cheddar cheese curing room at a temperature of 50–60 degrees F. and a relative humidity of 60–70 degrees. It is very likely that print cheese may be satisfactorily cured in cold storage, and that the cheese so cured will possess a minimum of rind, with an excellent flavor and texture.

This idea has not been patented by the writer; the cheese made at the Dairy School have been inspected by many visitors, including manufacturers and dealers, who have expressed themselves very favorably concerning the possibilities of the manufacture of print cheese.

INFLUENCE OF COLD-CURING ON THE QUALITY OF CHEESE.

S. M. BABCOCK, H. L. RUSSELL, A. VIVIAN AND U. S. BAER.

The temperature environment in which cheese is placed during the ripening period is known to exert a most profound effect on the quality and therefore on the value of cheese. Practical experience has shown that the poorly constructed curing room, which unfortunately is so commonly found, and in which the daily temperature variation follows quite closely that of the outside air, is not suited to the development of the most desirable flavor of cheese. In such rooms, where the temperature often reaches 80° F. or above, the cheese ripens very rapidly, and acquires not only a poor texture, but also a rank, sharp taste which is not acceptable to the general market. The failure to recognize the importance of controlling this factor of temperature costs the cheese industry of this country large sums every year, a tax which is levied and collected from ignorance and indifference, and which is out of all proportion to the cost of maintaining a suitable temperature control.

Experiments detailed in the Fourteenth Annual Report (p. 194) of this Station for 1897, may be referred to for confirmation of the effect of high temperatures (70° F. and above) upon the production of sharp and undesirable flavors.

In connection with investigations that have been made on the influence of low temperatures (below and somewhat above the freezing point), on the activity of galactase in cheese, we have been able to study the development of cheese flavors under temperature conditions much lower than those heretofore employed.

The work to be reported upon covers several different series of experiments which have been made during the last four

years. In some of these series it is believed that a sufficient number of cheese have been made to warrant conclusions of a rather definite nature. It will, however, be necessary to test the validity of these conclusions under varying commercial conditions before they can be unreservedly accepted in commercial practice.

It is to be regretted that experiments of this character must of necessity extend over such long periods of time, but this is a difficulty inherent to the question that can be met in no other way. The results obtained in the various series are herewith presented.

SERIES I.

The first experiment along this line was designed to show the effect of low temperatures on the activity of galactase. For this purpose two cheese were made on February 27, 1899, and sent immediately to Hoard's cold storage rooms at Fort Atkinson. These cheese were placed in the butter room at a temperature that was kept below freezing (25°–30° F.) for most of the time. They were removed at the end of 14 and 17 months, respectively, and examined chemically as well as for quality. These cheese showed a thoroughly broken down condition with an almost perfect texture, and an extremely mild flavor with no trace of any bitter or undesirable taint. They were utterly devoid of the sharp tang that is invariably found in old cheese ripened at high temperatures, indicating that the breaking down of the casein is to a large extent independant of the production of the peculiar flavor that is normally found in matured cheese ripened even under good temperature conditions (60°–65° F.).

The analytical data with reference to these cheese are as follows:

One cheese was removed from cold storage when fourteen months old, and another at the end of seventeen months. These were analyzed with the following results:

TABLE I.— *Chemical analyses of cold storage cheese.*

	Per Cent. of Nitrogen in Different Proteid Bodies.	
Age of Cheese When Analyzed	14 months.	17 months.
Albumoses	.39	.48
Peptones (precipitated by tannin)	.26	.13
Peptones (precipitated by phosphotungstic acid)	.12	.19
Amids	.31	.29
Ammonia	tr.	tr.
Total soluble N	1.08	1.09
Insoluble N. (casein, etc.)	2.63	2.50

Although these cheese were fourteen and seventeen months old and were perfectly broken down physically, yet the soluble nitrogenous bodies present were only about as much as are ordinarily found in a three months' old cheddar ripened at ordinary temperatures (60°–65° F.).

These cheese were examined bacteriologically when removed from cold storage and lactic acid-producing and inert species were found to predominate. Very few liquefying forms and no gas-producing organisms were obtained.

SERIES II.

A repetition of this experiment was begun in May, 1900, in which cheese were cured not only below freezing but at temperatures ranging from 33°–60° F. In this series, varying quantities of rennet extract were used in order to determine if an increased rate of ripening could not be secured in this way without detriment to quality. These cheese were made on successive days but those having the same amount of rennet were made on the same day and in the same vat.

They were examined at intervals of a few months apart, and at various times chemical analyses were also made. The results of these examinations are as follows:

TABLE II.— *Chemical analyses of cheese made with 3, 6 and 9 ozs. rennet and ripened from 15° to 60° F.*

Age in months.	Amt. rennet used.	PERCENTAGE OF TOTAL SOLUBLE NITROGEN (T. S.) AND AMID BODIES (AM.) INCLUDING AMMONIA.									
		15° F.		33° F.		40° F.		50° F.		60° F.	
		T. S.	Am.	T. S.	Am.	T. S.	Am.	T. S.	Am.	T. S.	Am.
0	3	.14	......	.14	......	.14	......	.14	......	.14	......
6	3	.56	......	.86	......	.77	......	.90	......	1.08	......
10	3	.60	.23	.90	.37	.80	......	.99	.42	1.16	.52
12	3	....	......	....	......	.98	.37	....	......	....	......
14½	3	.62	.24	1.02	.46	....	......	1.15	.54	....	......
0	6	.14	......	.14	......	.14	......	.14	......	.14	......
6	6	....	......	....	......	.88	......	....	......	1.24	......
10	6	.63	.22	1.05	.35	1.07	.34	1.11	.43	Spoil'd	......
14½	6	.87	.24	1.16	.46	....	......	1.27	.55	....	......
0	9	.14	......	.14	......	.14	......	.14	......	.14	......
6	9	.70	.12	.95	......	1.18	......	1.08	.26	1.65	......
10	9	.74	.22	1.13	.36	1.27	.38	1.26	.46	Spoil'd	......
12	9	....	......	....	......	1.56	.70	....	......	....	......
14½	9	.95	.24	1.40	.46	....	......	1.78	.54	....	......

INTERPRETATION OF CHEMICAL DATA.

A comparison of the cheese ripened at various temperatures and containing the same quantity of rennet shows that the amount of soluble nitrogenous bodies increases with the ripening temperature. Even the cheese kept below freezing (15° F.) showed a marked increase in soluble proteids, thus indicating that the decomposition of the casein can go on at extremely low temperatures where living organisms are not generally supposed to be able to develop. This point is of special interest, inasmuch as it raises the question as to the ability of non-vital ferments (enzymes) to act on organic matter under conditions which would seem to preclude the possibility of the development of living ferments (bacteria).

When cheese are ripened at varying temperatures, not only is the total soluble nitrogenous matter increased at the higher temperatures, but the lower decomposition products (amids including ammonia) are likewise larger. This increase of amido-

compounds is undoubtedly due to the facilitated activity of galactase at higher temperatures, and is wholly independent of the amount of rennet employed.

A comparison of cheese made with varying quantities of rennet and ripened at the same temperature shows that the increase in rennet is accompanied by an increase in total soluble proteids, which is wholly confined to those groups characteristic of peptic digestion, which we have previously shown to be due entirely to the pepsin contained in the rennet extract.[1]

While the ripening of cheese at low temperatures goes on slowly, and therefore necessitates a much longer curing period, this disadvantage may be overcome in a measure by the use of increased quantities of rennet. Reference to table shows that a nine-ounce rennet cheese, ripened for fourteen months even below freezing, contains almost as much soluble nitrogen as a ten-months'-old three-ounce rennet cheese ripened at 50° F. The action of increased rennet on the quality of the cheese will be noted under the following head, in which the commercial character of the cheese is discussed.

QUALITY OF CHEESE IN SERIES II.

As no facilities for temperatures below freezing were available at Madison, it was necessary to ship cheese to outside points for storage. Under these conditions it was impracticable to examine the cheese as frequently as desirable, and moreover, the inevitable fluctuations in the temperature of the curing rooms could not be closely watched.

During the early part of the curing period these cheese were only examined at intervals of some months, but later, more frequent tests were applied to determine the course of the ripening process.

Table III includes the numerical and descriptive scores as made by Mr. Baer, together with his estimate of the commercial value of the cheese, based on a ten-cent market.

Mr. Baer found great difficulty in comparing these cheese, the temperature of which differed so widely. To overcome this, the cheese plugs were drawn and placed in tightly stoppered glass

[1]17th Rept. Wis. Exp. Stat., 1900, p. 102.

tubes, and after they had warmed up were scored in the usual way. The last score made when sixteen and one-half months old was from plugs drawn from the warmed-up cheese, two days after removal from cold storage. These scores were invariably higher than those made from the warmed-up plugs and seems to indicate that it is more desirable to score from the cheese itself than from warmed plugs alone.

TABLE III.—*Scores and commercial value of cheese made with 3 ozs. of rennet, and ripened from 15°-60° F.*

Ripening temperature.	Lab'y No of Cheese.	Age in months when examined.	Comerc'l value (10c per pound stand'rd)	Numerical Scores.		Descriptive Scores.			Remarks.
				Flavor standard 45.	Text're 30.	Flavor.	Text.	Body.	Color.
15° F.	453	6	....	....	....	Low, clean.	Mealy ..	Close ...	Clear.
		10	8.75	40	21	Clean ...	Mealy...	Close ...	Even.
		11-½	8.5	39	22	Clean...	Mealy...	Close ...	Wavy specks.
		12-½	6.5	30	18	Sour....	Curdy ..	Loose, open.	Wavy specks.
		14-½	6.0	28	17	Sour,	Curdy...	Open ...	Wavy specks.
		16-½	6.75	30	24	Off.....	Mealy...	Close ...	Even.
33° F.	451	6	....	....	....	Good....	Sl. granular.	....	Clear.
		10	9.5	43	24	Clean, low.	Mealy...	....	Sl wavy.
		11-½	8.75	39	23	Low sl., off.	Mealy...	Fairly close.	Faded speck.
		12-½	7.5	37	22	Not clean.	Curdy, dry.	Close ...	Wavy speck.
		14-½	6.5	30	22	Not clean.	Curdy, dry. ..	Open	Bleached. specks.
		16-½	10.25	43	30	Not clean.	Silky ...	Close ...	Clear.
40° F.	445	3	....	....	....	Fine	Good ...	....	Clear.
		6	....	....	....	Fine	Good ...	....	Clear.
		8	10.0	40	29	Low, clean.	Good ...	Close ...	Clear.
		10	10.0	37	30	Clean, mild.	Good ...	Close .	Wavy.
		12	10.5	42	29.5	Clean...	Good ...	Close ..	
50° F.	449	6	....	....	....	Fair	Mealy...	....	Clear.
		10	9.5	43	22	Clean...	Mealy...	Sl. open.	
		11-½	8.5	35	22	Not clean.	Mealy...	Close ...	Wavy specks.
		12-½	8.5	35	24	Off......	Mealy...	Close ...	Specks.
		14-½	8.75	38	22	Off.	Mealy...	Close....	Bleached.
		16-½	7.75	33	24	Musty..	Mealy...	Close...	Wavy specks.
60° F.	446	5	....	....	....	Sharp, clean.	Fine	....	Clear.
		6-½	....	....	....	Good....	Fair	....	Clear.
		7-½	8.75	36	24	Fair	Mealy, dry.	Sl. open.	Wavy bleached..
		10	....	25	17	Bitter...	Mealy ..	Open....	Badly bleached.

Scores and commercial value of cheese made with 6 ozs. of rennet, and ripened from 15°-60° F.

Ripening temperature.	Lab'y No. of cheese.	Age in months when examined.	Commercial value (10c. per pound standard).	Numerical Scores. Flavor, standard 45.	Numerical Scores. Text're 30.	Descriptive Scores. Flavor.	Descriptive Scores. Texture.	Descriptive Scores. Body.	Remarks. Color.
15° F.	459	6	....	....	....	Clean...	Sl. granular.	....	Clear.
		10	10.0	44.5	29.5	Clean, low.	Waxy...	....	
		11-½	8 25	36	25	Clean, low.	Curdy...	Loose ..	Faded specks.
		12-½	7.25	34	22	Sour. ...	Curdy...	Open. ..	Cut specks.
		14-½	6.12	28	21	Sour....	Curdy...	Loose ..	Wavy specks.
		16-½	7.00	30	28	Fishy. ..	Fair	Close ...	Clear.
33° F.	457	6	....	....	....	Ideal ...	Silky....	Close ...	Clear.
		10	10.00	44.5	26	High....	Flinty ..	....	Sl. wavy.
		11-½	8.75	38	26 5	Clean, low.	Fair	Loose ..	Wavy specks.
		12-½	8.50	39	25	....	Sl.mealy	Close...	Cut.
		14-½	7.25	31	22	Not clean.	Pasty...	Loose ..	Bleached specks.
		16-½	9.00	40	24	Little off.	Sl.sticky	Close ...	Wavy.
40° F.	441	5	....	....	....	Good ...	Good ...	....	Wavy.
		6-½	....	....	....	Fine	Good ...	....	Clear.
		7-½	11.00	44.5	29	Extra fine.	Perfect..	....	Clear.
		10	10.5	42.5	28	Clean, good, low.	Good. ..	....	
		12-½	10.0	41	28	Clean...	Wavy...	Close. ..	
50° F.	455	6	....	....	....	Clean...	Fine....	Close...	Clear.
		10	10.5	44	28	Good, high.	Smooth, waxy.	....	Wavy.
		11-½	8.75	38	26	Clean...	Mealy ..	Close. ..	Bleach'd
		12-½	9.25	40	28	Clean, low.	Sl.mealy	Close. ..	Mottled specks.
		14-½	7.75	34	25	Fairly clean.	Mealy ..	Close. ..	Mottled specks.
		16-½	9.0	38	27	Sharp, not clean.	Fair	Sl. loose.	Wavy.
60° F.	442	3	....	....	....	Bad.....	....	....	Cloudy.
		5	....	....	....	Sharp.			
		6-½	....	....	....	Swe'tish	Pasty...	Loose ..	Cloudy.
		7-½	5.50	26	28.5	Bitter, sharp.	Waxy...	Loose..	Mottled.

Scores and commercial value of cheese made with 9 ozs. of rennet, and ripened from 15° to 60° F.

Ripening temperature.	Lab'y No. of cheese.	Age in months when examined.	Commercial value (10c per pound standard).	Numerical Scores. Flavor, standard 45.	Numerical Scores. Text're 30.	Descriptive Scores. Flavor.	Descriptive Scores. Texture.	Descriptive Scores. Body.	Remarks. Color.
15° F.	462	6	....	....	....	Bitter ..	Fair	....	
		10	9.75	40	27	Clean, mild.	Waxy ..	.. ..	Even.
		11-½	9.83	40	26	Clean, mild.	Curdy ..	Close....	Even specks.
		12-½	8.0	37	24	Sour....	Curdy ..	Close ...	Even specks.
		14-½	7.75	37	23	Sl. sour	Curdy...	Loose ..	Wavy.
		16-½	7.00	34	25	Off......	Sticky ..	Loose ..	Wavy.
33° F.	463	6	....	......	....	Bitter ..	Pasty...	....	Clear.
		10	8.50	37	21	Swe'tish not clean.	Pasty...	....	Even.
		11-½	8.0	32	28	Off	Good....	Close....	Even specks.
		12-½	9.5	42	29.5	Low....	Good ...	Close ...	Even specks.
		14-½	9.5	42	29.5	Clean ..	Smooth.	Close ...	Even specks.
		16-½	10.5	44	30	Clean, high.	Waxy...	Close ...	Even specks.
40° F.	443	5	....	....	....	....	Good ...	....	Cloudy.
		6-½	....	....	....	Fine ...	Sl. pasty	....	Cloudy.
		7-½	9.0	36	28	Sweet...	Sl. pasty	....	Faded.
		10	10.5	43	30	Nearly perfect	Perfect..	Close. ..	
		12-½	11.0	44	30	Clean...	Waxy. ..	Close. ..	
50° F.	465	6	....	. ...	....	Fine....	Silky....	Close ...	Clear.
		10	10.5	45	30	Clean, ideal.	Perfect .	....	Even.
		11-½	10.5	45	30	Fine....	Perfect..	Close ...	Even specks.
		12-½	10.5	44	29.5	Clean, high.	Sl. mealy	Close ...	Even specks.
		14-½	9.0	30	25	Not clean, moldy.	Dry	Close ...	Even specks.
60° F.	444	3	....	....	....	Bad	....	....	Cloudy.
		5	....	....	....	Sharp ..	....	....	
		6-½	....	....	....	Bad	Sticky ..	Loose, open.	Mottled.
		7-½	0	20	14	Rotten..	Sticky ..	Loose, open.	Mottled.

Cheese made with normal amounts of rennet (3 ozs. per 1,000 lbs. milk).—When this series of cheese, made with normal amounts of rennet (3 ozs. per 1,000 lbs. milk) and ripened at temperatures ranging from 15°–60° F., is considered as a whole, it is to be observed that for the first twelve months of the curing period, the flavor was perfectly satisfactory with no trace of bit-

terness or undesirable taints. Beginning with the score made at twelve and one-half months, the flavor was slightly sour, which condition became intensified with increasing age. It should, however, be noted that this condition was not confined to the lower curing temperatures but was even more pronounced with those temperatures that have heretofore been considered ideal (50°–60° F.). This would seem to indicate that the impairment in flavor was not so much attributable to the low ripening temperature employed as to some condition inherent in the milk or method of manufacture. This fact is emphasized when one considers that a cheddar cheese made with 3 oz. rennet per 1,000 lbs. milk, and ripened at 60° F., ought to have been in prime condition at any time up to the end of this experiment. In the case of this cheese, a bitter flavor was noted when ten months old, and deterioration is observable from the first, in view of the fact that the color became cloudy and bleached when only seven and one-half months old. In the cheese cured at 15°, 33°, and 40° F., the flavors were generally low and clean with the exceptions above noted. In the higher temperatures the flavors were more pronounced, although they did not score numerically any higher than those cured at the lower temperatures.

With reference to texture, this whole series is slightly too dry, thus tending to mealiness, a condition determined by method of manufacture. In body and color the lower temperatures gave better results throughout, a meaty body and even color prevailing for at least a year.

Cheese made with 6-oz. rennet per 1,000 lbs. milk.—In Table III is detailed similar records regarding the cheese of this series made with double the quantity of rennet. This was done to determine the influence of higher rennet on the length of the curing period and on the quality of the product when ripened at relatively low temperatures.

In this set, the flavor was improved in all cases except the highest temperature (60° F.), which went "off" rapidly. Even at freezing temperatures the flavor was clean and nearly perfect, scoring 44.5 at ten months. Subsequently these cheese, and to a less extent those cured at 33° F., became slightly sour, similar to those made with the lower amount of rennet. The cheese

cured at 40° and 50° F. were of excellent quality, both as to flavor and texture. The higher rennet gave a somewhat more open body which was greatly pronounced at the higher temperatures (see figs. 34, 35). The same condition was noted with reference to color, the cheese becoming mottled and then bleached, whenever there was a tendency toward openness in body. This was less marked at lower temperatures and did not appear until later in the life of the cheese.

FIG. 34.—Texture of cheese ripened at 40° (lower cheese) and 60° F (upper cheese) High temperature cut the value of this cheese several cents per pound.

Commercially, these cheese were better than those made with normal rennet, except those cured at 60° F. At this temperature or above, six ounces of rennet is detrimental, but when cured at 50° F. or below, this increase in rennet facilitates the ripening without impairing the quality. The best cheese were those ripened at 40° F., which were rated at seven and one-half months higher than standard values. Even those ripened at 33° and 15° F. were up to standard when ten months old.

Cheese made with 9 ounces of rennet per 1,000 lbs. of milk.—Table III shows the effect of three times the usual amount of rennet. This increase of rennet still further hastens the curing

process at all temperatures. The flavor of these cheese was much better at temperatures below 50° F. than when only three ounces of rennet were used, but as would be expected, was greatly impaired at 60° F. At 40° and 50° the flavor was nearly perfect at all periods of the ripening. Even after fourteen and one-half months no bad flavor was noticed except that caused by molds which had developed in the numerous holes made by removal of samples. The texture of all cheese except those ripened at 60° was better than when less rennet was used. Those ripened at 40° and 50° F. had nearly a perfect texture throughout the whole experiment. In spite of the high quantity of rennet employed no bitter or other disagreeable flavors usually associated with the use of high rennet was found at the temperature of 50° F. and below. Commercially the cheese kept at 40° and 50° scored above the standard.

WHITE SPECKS IN CHEESE.

One very peculiar condition was noted in all of these cheese held at temperatures of 50° F. or below, and that was the appearance of small white specks that were more or less uniformly distributed throughout the whole substance of the cheese. These were found not only in all of the cheese containing three ounces of rennet and ripened at 50° F. or below, but were equally numerous in the remainder of this series which contained six and nine ounces of rennet per 1,000 lbs. of milk.

Further, we may say that all succeeding series kept under these temperature conditions have shown this same peculiarity. The appearance of this condition had not heretofore been noticed by us in cheese and upon inquiry among cheese dealers who handle cold storage stock, it was found that some had observed such a phenomenon, but considered it of no consequence, as it did not affect the commercial value of the cheese. Mr. Baer has since found this condition more or less pronounced in a number of cold storage plants in the state.

In our experience these specks can only be recognized with the closest scrutiny if examination of the plugs is made when first drawn. If, however, such plugs are allowed to warm up, these tiny opaque white points become pronounced and readily

distinguishable from the translucent yellowish body of colored cheese. The nature of these specks and the conditions governing their appearance are subjects still under investigation. It was thought that this condition would be more obscured in uncolored stock, but experiments made on this point show that the white speck appears even under these conditions. The appearance of these specks did not affect the flavor or general quality of the cheese.

COMMERCIAL VALUE.

When judged by the commercial value placed on these cheese by Mr. Baer at time of scoring, it is to be noted that the price per pound was higher for cheese ripened at 40°–50° F. than for the higher temperature. Even the value of the cheese ripened at freezing or below was equal to or better than the value of the 60° F. product, but of course the increased period of curing necessary at these lower temperatures renders this process more expensive.

The use of lower curing temperatures also results in a much less marked development of mold. Although these cheese were cured in boxes, those kept at 40° F. and below developed little or no mold for nearly a year. At this time those ripened at higher temperatures were completely covered with a black coating of mold. In the later history of the low temperature cured cheese some mold did develop, but even the worst cases did not reach a development that almost always accompanies the ripening of cheese in rather moist rooms kept at higher temperatures.

DISCUSSION OF RESULTS OBTAINED IN SERIES II.

In this series, made with varying quantities of rennet, it is markedly noticeable that the increase of rennet over the normal (3 ozs. per 1,000 lbs. of milk) materially affects the rate of ripening, and therefore the commercial life of the cheese. This rate is directly dependent upon the curing temperature. With the cheese made with the higher quantities of rennet and ripened at the highest temperature employed (60° F.), the quality of the cheese was impaired to such an extent as to render the product practically worthless at all stages. This condition was less ob-

servable with the smaller quantities of rennet, but even where only three ounces were used the period at which the cheese was saleable was only of a few months duration. It should be borne in mind that these temperature conditions have heretofore been considered as quite satisfactory for the proper curing of cheese. It should also be noticed in this series that on account of either a poor condition of the milk or the method of making, the "life" of the cheese was considerably shorter than that of a first-class Cheddar made under more favorable conditions.

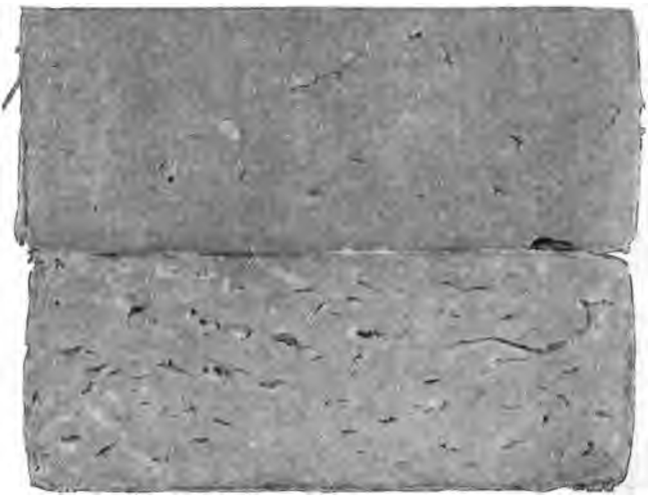

FIG. 35.—Texture of cheese made with three ounces of rennet and ripened at 33° and 60° F. Note the influence that temperature exerts on texture and color of cheese.

When the cheese of this set were compared with those containing varying quantities of rennet and ripened at lower temperatures (15° to 50° F.), the character of the cheese was without exception better, except at the lowest temperature (15° F.). With this exception the effect of these lower temperatures was to prolong the period during which the cheese were saleable, although it must be kept in mind that under these conditions the rate of ripening was retarded.

The relation of temperature and quantity of rennet to the commercial life of the cheese can perhaps be more readily understood by reference to the schematic diagram presented (fig. 36). In this diagram mathematical accuracy is not attempted

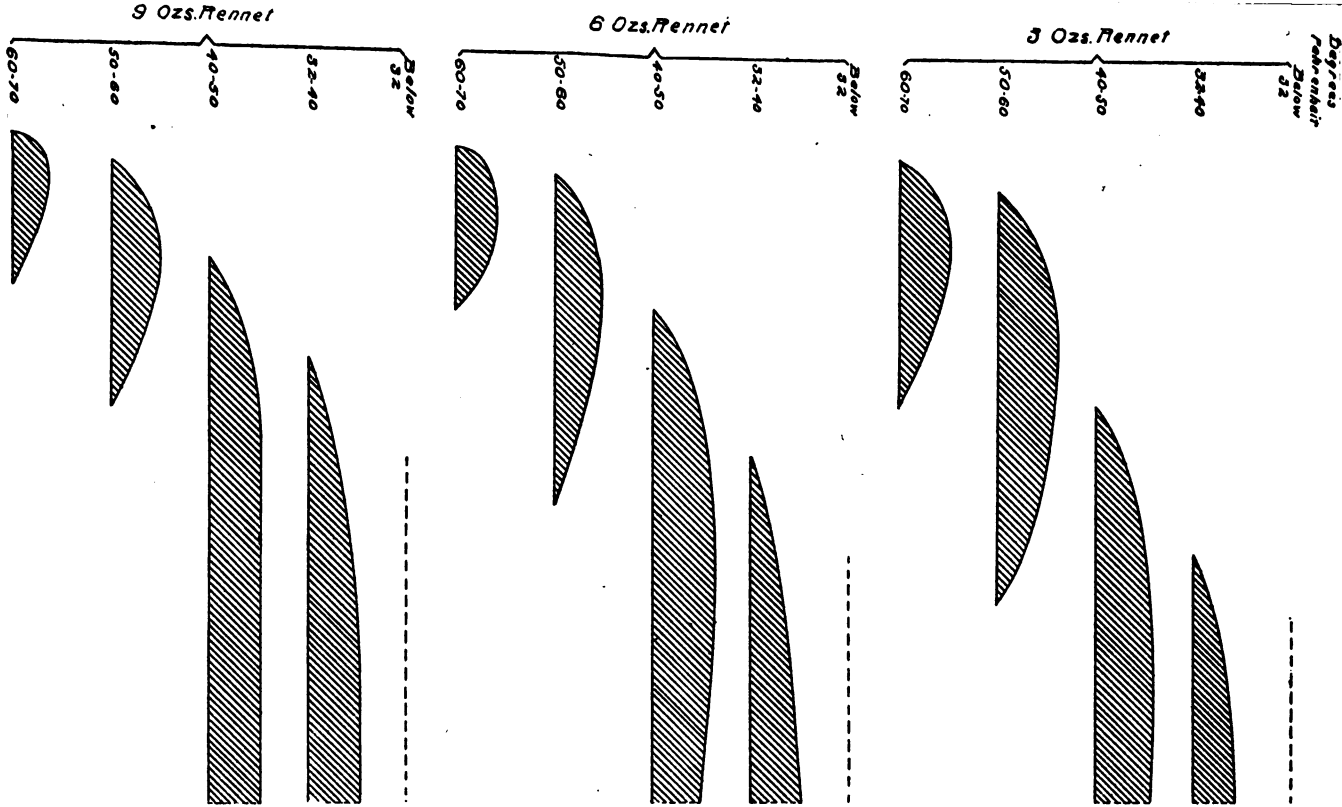

FIG. 36. Schematic diagram showing commercial "life" and relative value of cheese cured at different temperatures. Horizontal distance represents time limit, the beginning of the curve indicating the relative period when cheese began to be marketable. The length of curve signifies the relative keeping quality of the different cheese. The dotted line indicates that such cheese had no commercial value. The amplitude of the curve represents the relative value per pound. *The increased keeping quality and enhanced value of low temperature-cured cheese is especially to be noted.*

but simply the general relation is presented. From the observational data reported in Table III, it is apparent that high rennet and high temperatures are incompatible, but that high rennets are advantageous when the ripening temperature is kept at 50° F. or lower. Such cheese ripen more rapidly and are devoid of all sharp flavors that accompany the use of large amounts of rennet at higher temperatures (60° F. and above).

In those experiments in which cheese were kept below freezing (15° F.), the casein of the cheese is to a considerable extent rendered soluble, but the physical symptoms of ripening are not marked, although this is more pronounced when larger quantities of rennet were used. The cheese kept at 15° F. while promising well for the first year of the curing period, later went "off" in flavor, a condition quite different from that found in Series I. It is doubtful whether this should be wholly attributed to the influence of the low curing temperature, when it is observed that the flavor of the cheese made with three ounces of rennet and ripened under normal conditions was impaired in course of time at all other temperatures.

3 ozs. 6 ozs. 9 ozs.

FIG. 37.—Cheese made with three, six and nine ounces of rennet and cured at 40° (lower row) and 60° F. (upper row).

In the above series the best results were obtained from a commercial point of view when the cheese were cured from 40°–50° F. At these temperatures it appears to be permissible to use two or three times the normal amount of rennet. The accelerated rate of ripening without impairment in quality renders the use of these larger amounts of rennet desirable. Whenever

extra quantities of rennet are used, it is necessary to place the cheese at a low temperature very soon after they are taken from the press.

RELATION OF BODY AND TEXTURE TO CURING TEMPERATURE AND AMOUNT OF RENNET USED.

The effect of a variation in amount of rennet used and the temperature at which the cheese is cured on the body and texture is strikingly shown in fig. 37, which includes the series of cheese containing 3, 6 and 9 ounces of rennet at 40° and 60°. From this figure it is evident that the larger amounts of rennet in cheese ripened at 40° makes even a better body than the normal amount of rennet at 60°. Compare in Fig. 37 (opposite page) upper left hand cheese (3 ounces at 60°) and lower right hand cheese (9 ounces at 40°). These cheese are shown on a larger scale in figs. 38 and 39. Similar results were obtained with reference to body with the cheese cured at 15° and 33° F., but when these cheese are left in storage for long periods of time the close meaty body disappears.

FIG. 38.—Cheese containing three ounces of rennet and ripened at 40° and 60° F. (upper).

It is noteworthy that when the color of any of the cheese is bleached that

it bears a close relation to the formation of the irregular ragged holes that generally characterize a high temperature cured cheese. This is shown particularly well in Figs. 34–39, in which the ragged holes are generally surrounded by a bleached area. This follows the division lines of the curd particles and precedes the formation of the ragged holes.

FIG. 39.—Cheese containing nine ounces of rennet and ripened at 40° and 60° F. (upper).

With the cheese cured at subnormal temperatures, 15°–33°, the color was clear for the first twelve months. Later these cheese became wavy in color and it should be noted that at the same time the body of the cheese changed from close to loose.

SERIES III.

On March 15, 1901, another set of cheese made at the Dairy School from normal milk (3.9% fat), with three ounces of rennet per 1,000 pounds milk, was taken for an experiment and ripened at 15°, 40° and 60° F. These cheese have been examined at two, three, five and seven months and the following scores recorded at these respective ages. This experiment is not yet completed, but results are submitted down to date as shown in table IV.

TABLE IV.--*Scores of cheese in Series III. Cured at 15°, 40° and 60° F.*

Curing temperature.	Lab'y No. of cheese.	Age in months when examined.	Commerci'l value (10c per pound stand'rd)	Numerical Scores.		Descriptive Scores.			Remarks.
				Flavor, 45.	Text're 30.	Flavor.	Texture.	Body.	Color.
15° F.	19	2	9	40	27	Clean...	Curdy.	Close....	Even.
		3	....	......	......	....	....	....	
		5	7	30	22	Musty...	Curdy...	Open....	Wavy.
		7	8	38	24	Fair.....	Curdy, soggy ..	Loose...	Wavy.
40° F.	17	2	8.32	41	25	Clean...	Curdy...	Close....	Even.
		3	9	38	27	Clean...	Curdy...	Close....	Even.
		5	9	38	27	Clean...	Curdy...	Close....	Even.
		7	10	41	29	Clean, low....	Silky....	Close...	Even.
60° F.	18	2	8	34	23	Sl. off...	Curdy...	Close....	Even.
		3	10	40	28	Clean..	Silky ...	Close....	Even.
		5	11	45	29	Clean, high.	Silky ...	Close....	Even.
		7	9.75	40	27	Clean, sharp..	Sl. mealy..	Fairly close...	Even.

DISCUSSION OF RESULTS OBTAINED IN SERIES III.

This series is included in an experiment made to determine the influence of varying quantities of fat on the ripening at different temperatures. Only the cheese made from normal milk are, however, included in the data here presented.

From Table IV it appears that the cheese ripened at 60° F. was of excellent quality when three to five months old. That kept at 40° F. did not of course develop as rapidly, but it should be noted that at the time of last scoring (seven months old) it was superior to the one kept at 60° F., but had not yet reached its prime, especially as to flavor. The lengthening of the commercial life of the cheese at the lower temperature is evident when compared with the one kept at 60° F., which at time of writing was considerably past its prime.

The cheese kept at 15° F. is now only of fair quality, the texture being soggy and body open.

The result of this test is in accord with those obtained in the preceding series.

SERIES IV.

Realizing the advisability of using milk from different regions, and also making a large number of cheese from the same milk, a new series of experiments was started in May of the current year. Mr. Baer made this series at one of the factories of Mr. H. J. Noyes of Muscoda, Grant county. Normal milk was used and the ordinary quantity of rennet extract (three ounces) employed. These results are presented to date, but this experiment also will not be completed for the lower temperatures for some time to come. The data here presented in Table V is therefore simply a progress report:

TABLE V.— *Scores of cheese in series IV.*

Curing temperature.	Lab'y No. of cheese.	Age in months when examined.	Commercial value (10c. per pound standard.)	Numerical Scores.		Descriptive Scores.			Remarks.
				Flavor, standard 45.	Text're 35.	Flavor.	Texture.	Body.	Color.
15° F.	76	1	7.0	35	22	....	Curdy ..	Close ...	Even.
		3	6.5	32	20	....	Curdy ..	Loose ..	Even.
		5	6.0	30	22	Not developed	Soggy, curdy .	Loose ..	Even.
40° F.	81	1	8.0	34	24	....	Curdy...	Close ...	Even.
		3	8.0	35	24	....	Curdy ..	Close ...	Even.
		5	10.0	42.5	28.5.	Clean, low.	Fair	Close ...	Even.
50° F.	77	1	8.5	37	25	....	Curdy ..	Loose...	Even.
		3	8.75	38	26	Clean. ..	Silky ...	Close ...	Even.
		5	10.25	43½	30	Clean. ..	Waxy...	Close ...	Even.
60° F.	94	1	10	41	30	Clean. ..	Silky ...	Sl. open.	Even.
		3	10	41	27	Clean. ..	Good .	Sl. open.	Even.
		5*	....	....	....	....	....	....	

* Spoiled because of excessive moisture in new curing cellar.

DISCUSSION OF RESULTS OBTAINED IN SERIES IV.

In this series, the cheese cured at the usual curing temperatures (60° F.) were for the first few months of excellent quality, thus indicating that so far as milk and manufacture of product were concerned, good results were to be expected from this series. The cheese kept at this temperature were placed in the new underground curing cellars at the dairy building immediately after their completion, and before the same had dried out.

The excessive moisture under these conditions injured the quality of the product so that when examined at the five months' period they were discarded as unfit for further use.

The cheese cured at 40° and 50° F. both continued to improve with age and at the present time (five months old) are practically perfect in texture, but are a little low in flavor. They score now above the market standard, and if further development of flavor should continue will undoubtedly improve in value.

FIG. 40.—Cheese ripened at 15° F.

Those kept at freezing temperature (15°), while partially broken down to the touch, have a soggy, curdy texture, and the flavor is, as yet, entirely undeveloped. They will probably not develop into cheese of even an average quality, if kept at these low temperatures.

In addition to the cheese above described in this series, eight other cheese made from the same milk were taken and kept in a cold curing room from 50°–60° F. for two and four weeks before they were placed under the same temperature conditions as the cheese of this series. This was to determine the influence of preliminary ripening before cold storage curing, and the results will be presented later.

Without a single exception these results accord with those before presented. The cheese kept at 40° and 50° F. were in all cases valued from one-eighth to one-half cent per pound above the ten-cent standard. In flavor they ranged from 42.5 to 44, being marked down from perfect (45) only because they had not developed quite as high flavors as required by market demands.

The texture of these cheese was almost perfect in all cases. Those stored at 15° were improved over those placed at such temperatures directly from the press, but were not up to standard quality.

FIG. 41.—Showing texture of cheese cured at 40° (waxy) and 60° F. (crumbly).

The general conclusion from this series of experiments substantiate that drawn from the preceding series and indicates that temperatures ranging from 40°–50° F. may be employed with perfect safety and with advantage for the curing of Cheddar cheese, even when such cheese are placed at those temperatures directly from the press. One great advantage gained under these conditions is the lengthening of the period during which the cheese is at the highest state of perfection. In no case was there found any semblance of a sharp, bitter, or in anywise disagreeable flavor, and while the flavor was somewhat mild, the texture of the cheese was beyond criticism.

GENERAL CONCLUSIONS.

Influence of low temperature curing on quality of cheese.—In these experiments we have attempted to determine the influence of lower than usual temperatures on the curing of Cheddar cheese. The results obtained seem to warrant the conclusion that these temperatures may be employed with perfect safety, despite the fact that such have been generally regarded as producing bitter flavors. Not only have we found in our experiments that no bitter or other undesirable flavors have been produced, but that the quality of cheese cured under these conditions was

on the whole better than that of those ripened at the more usual temperatures employed (60° F. and above).

Good results have been obtained at all temperatures from 33° to 50° F., although more uniform results were obtained from 40°–50° F. This indicates that the ordinary temperatures secured in cold storage rooms are suitable for this purpose. The experiments made at temperatures below freezing show that the course of ripening is not normal and these cannot be recommended for general practice, although the casein of cheese breaks down even under these low temperature conditions.

1. *Flavor.*—As the rate of ripening is considerably retarded by the lower temperatures used, the intensity of flavor found in these cheese was naturally less than with cheese ripened at higher temperatures. Even though the low-temperature cheese were ripened for longer periods, the flavor was always mild, indicating that the character of the decomposition products was different. In no case was there any of the sharp flavors that characterize old cheese ripened at the usual temperatures. This fact is very significant in indicating that the physical breaking down of the casein and the production of the peculiar flavors that characterize ripe Cheddar cheese are quite independent of each other, although under normal temperature conditions the two processes progress simultaneously.

2. *Texture.*—The effect of these low temperatures on texture is very marked. Almost without exception in the cheese cured above freezing, the texture was improved over that noted in the higher temperatures. In the earlier stages it had a tendency toward curdiness, but broke down into a waxy texture in time. When such cheese were examined chemically, the soluble nitrogenous products were never as large as the physical appearance of the cheese seemed to indicate, showing that the breaking down of the casein is not necessarily associated with soluble products. Below freezing a soggy, crumbly texture was often noted.

3. *Body and color.*—Generally a meaty body of a good cheese has a tendency to become loose as the cheese gets older, and the color is also cut more or less. This effect is intensified, especially when large amounts of rennet are used. This condition is much less marked in cheese cured at those lower temperatures in which the body remained quite firm and the color even.

White specks in cold cured cheese.—In all the cheese cured below 40° F. small, opaque whitish specks were produced which were scarcely noticeable when the plug was cold but became apparent upon warming. An examination of cold storage goods in various places revealed the fact that this was a common occurrence and in the judgment of buyers was neglected as a factor in determining values, as these specks were generally inconspicuous and apparently had no effect on the flavor of the product. The nature of these bodies is yet under investigation.

In all of the experiments detailed above the cheese were placed in cold storage direct from the press and the results obtained indicate that such cheese are sufficiently firm to hold their shape and bear storage well. Generally cold storage goods are given a preliminary cure for a week or so to develop a rind and start the flavor but this is frequently dangerous in factories not provided with proper curing rooms.

The cheese in these experiments that were ripened from the freezing point to 50° F. were of better quality on the whole than those ripened at higher temperatures and were judged by various experts as worth more than the market price.

Enhancement of keeping quality.—Ordinarily a cheese ripened at usual temperatures (60° F. or above) reaches its optimum condition within a few weeks, and unless sold at that time, loses considerably in value. When such cheese is placed in cold storage, this condition may be maintained for a considerable period of time, but not nearly so long as when the cheese is ripened throughout the whole period at those lower temperatures. This enhancement in keeping quality renders the dealer more independent of market fluctuations and enables him to secure maximum values for his product.

Diminution in losses from mold and drying.—When cheese is ripened at 60° F. or above, the losses due to shrinkage from drying and effect of mold are considerable. With the cheese cured at 50° F. and below, this loss was much reduced, and where cured at 40° F. or below, practically all mold growth was prevented. These low-temperature cured cheese were frequently taken from the boxes with perfectly clean sides, the only mold being next to the scale boards.

Cold curing vs. present curing methods.—The tendency within recent years has been to use lower temperatures for ripening than were formerly employed. Experience has shown that high, inequable temperatures injure materially the flavor, texture and keeping quality of the cheese, thereby diminishing considerably the value of the product. In practice these temperatures have gradually been reduced from the neighborhood of 70° F. to 65°, and later to 60° F. After cheese has been ripened at these temperatures, they have been stored in cold storage rooms until wanted for consumption.

The system of cold-curing here proposed differs from simple cold storage of ripened cheese in that these low temperatures are employed from the beginning of the ripening period. In our experience the quality of such cheese, as measured by the standards of flavor, texture and body are materially improved, with the result that the value of the cheese per pound is somewhat increased, and particularly so when the lengthening of the commercial period of the cheese is taken into consideration. Not only is the value per pound improved but the losses due to mold and shrinkage are diminished.

This system of curing has been tried under commercial conditions by a number of the leading cheese dealers in the state during the current year, and it is noteworthy that the highest prizes taken on cheese at the Wisconsin State Fair at Milwaukee, the Northern Wisconsin Fair at Chippewa Falls and the Inter-State Fair at La Crosse this fall were awarded to cheese that were practically cured on this plan, being placed at low temperatures within a few days from the press.

It should be kept in mind that the expense of this system of curing is somewhat greater than the old method, but the returns will undoubtedly more than balance the debit side.

So far as our knowledge goes this system of curing cheese from the press at low temperatures (below 50° F.) has not been tested before. In 1897, experiments were conducted at this Station,[1] where cheese were cured at refrigerator temperatures (50° F.), 60–65°, 70° and above, in which it was found that the cheese ripened at 50° F. were fully as good as those cured at

[1] 14 Rept. Wis. Station, p. 208.

60° F. and much better than those cured at the usual ripening temperatures (65–70° F). At the expiration of these experiments these low-temperature cured cheese were still in their prime, while those cured at 70° F. had greatly deteriorated. Since these experiments were reported, further tests have been made at other experiment stations which fully confirm the conclusions then drawn. Dean[1] at the Ont. Agr. College experimented with cheese cured at 60°, 65° and 70° F. and found that those cured at the lowest temperature were the best, not only as to flavor, but texture and color.

McKay[2] reports similar results in the case of Canadian cheese shipped to Iowa to be cured, as well as home-made cheese, where temperatures ranging from 55° F. and upwards were employed. Better results were also here obtained at the lower temperatures.

The New York (Geneva) station[3] has been conducting experiments along this line, curing cheese at temperatures ranging from 55° to 70° F. The results reported show without exception a marked improvement in the cheese kept at 55° F. over those ripened at higher temperatures.

While none of the above experiments were conducted at lower temperatures than 50° F. the results show that the best cheese were always those cured at the lowest temperature employed.

The working hypothesis on which the experiments detailed in this report have been made has been to determine at how low a temperature cheese could be cured, and after having shown that these changes go on at freezing temperatures or even below, the next question was to find the most favorable temperatures for commercial practice.

Application of this system to consolidated curing plants.— Some years ago we advanced the idea of curing cheese in central stations erected primarily for the purpose where proper conditions could be maintained more perfectly and at less expense than in the individual factory. This idea has met with some favor and several syndicates have adopted this system of curing, shipping the product of the several factories to a centrally lo-

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[1]Rept. Ont. Agr'l Coll., 1899, p. 59.

[2]Bull. 57, Iowa Expt. Stat., April, 1901.

[3]Bull. 184, N. Y. (Geneva) Expt. Stat., Dec., 1900.

cated plant built especially for the curing purposes. If the system of cold-curing here proposed should result in producing an improvement in quality of cheese as these experiments seem to indicate, this idea of consolidated curing stations could be very advantageously employed. In this way, the expense of cold-curing could be materially diminished, and while the process requires a longer period of time, and therefore somewhat greater expense in maintenance and interest charges, still the fact that the factories can dispense with the construction of adequate and properly constructed curing quarters will much more than offset the above factors. This system will naturally result in very much better care being given to the curing, under the control of a single person, who should be an expert on this phase of the work, than would likely obtain where the ripening is completed in the individual factories. The increased uniformity of the product, the larger lines to be handled, and the increased facilities for examination and shipment are all minor factors in favor of this system.

INFLUENCE OF SUGAR ON THE NATURE OF THE FERMENTATIONS OCCURRING IN MILK AND CHEESE.

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The cheese industry differs from the butter industry in that when the product is made it is not ready for consumption. However carefully the manufacturing details are carried out, the character of the product is not determined until the ripening changes have taken place, which process requires a considerable lapse of time. The character of these changes determines the flavor and the texture of the cheese, upon which is based the commercial value of the product. We have previously pointed out[1] that it is possible in these series of phenomena to differentiate in part at least between the breaking down of the casein and the production of the peculiar flavors that characterize the various kinds of cheese.

Our earlier efforts in studying the phenomena of cheese ripening have been directed in the main to a consideration of the causes that are concerned in the transformation of the insoluble curd into soluble products, *i. e.*, the breaking down or ripening of the curd.

The generally accepted idea as to the nature of the causes concerned in the production of flavor is that it is attributable to the by-products formed by the development of bacteria and other micro-organisms in or on the cheese. This view receives support from the fact that all varieties of cheese made with rennet are practically devoid of proper cheese flavor when they are first taken from the press. Bacteriological examination of cheese

[1]This Report, page 157.

shows that bacteria are present in large numbers, and capable of rapid development under these conditions. This fact has strengthened the notion that these changes were due to biological causes, and for some years past, investigators have attempted to isolate from different varieties of cheese, the specific organisms that were thought to produce the peculiar flavors. With the common types of cheese (cheddar, Swiss, etc.), these attempts have not been attended with marked success, although in the case of the moldy cheese (Roquefort, Stilton and Gorgonzola), specific mold organisms are used as starters to produce the characteristic flavors.

Inasmuch as the environment in which cheese is placed is the most important factor in determining what kind of a cheese will be produced, it would seem that a study of this phase of the question would be more likely to be suggestive than an attempt to isolate specific ferments.

From the same milk, scores of different varieties of cheese may be produced. These would necessarily contain the same kind of organisms, and therefore produce the same type of fermentation, unless in the manufacture and subsequent curing of the cheese, conditions prevailed that would modify the nature and action of the flavor-forming agents. If flavors are produced by living organisms, it is easy to see how a variation in the environment might radically affect the character of the flora found in the ripening cheese in contradistinction to that which was originally present in the milk, for it must be conceded that the milk originally contains not a single specific kind of organism but a more or less mixed flora. It is also possible that a variation in environment may even change the nature of the by-products formed by a specific organism. Again, there is evidence at hand indicating that the activity of non-vital ferments as enzymes is greatly affected by variation in environmental conditions (temperature, reaction, moisture, etc.).

The operation of this principle that environment largely determines the character of life in any given habitat is to be seen on every hand. This law controls the distribution of animal and vegetable life over the surface of the globe. A self-evident example can be noted on the bank of any shallow pond. The

outermost limit of plant growth is made up of sedges and reeds which are able to withstand a large amount of water. As a pond slowly fills up from land wash, or if it is drained off, the characteristic plant life soon undergoes a change. The water-loving reeds and rushes disappear and are replaced by plant forms that are adapted to a drier soil. Here the moisture content of the soil is the determining factor that governs the nature of the covering flora, but other environmental influences are equally operative. Note the character of the plant growth in a forested area, and then again after the timber has been removed. The one contains those plant forms that are adapted to shady locations; the other supports a flora that develops best in bright light. These illustrations could be multiplied indefinitely not only from the plant but the animal world. The law underlying this series of phenomena is equally operative with microscopic forms of life, and there can be no question but that the predominance of any kind of bacteria in any given habitat is to a very large extent determined by the nature of the environment. While it follows that any kind of fermentation can only occur when the specific organisms capable of producing such changes are present, yet the predisposing factor that determines whether such organisms will thrive and grow luxuriantly is controlled by the surroundings under which the organisms are placed.

Common experience of cheese makers recognizes the potency of environmental conditions in determining the character of by-products formed in cheese. A cheddar cheese differs from a Swiss or a limburger, not because of any inherent difference in the character of the milk used, but because the milk is handled and the cheese ripened in a way that changes the nature of the fermentation which takes place. A Cheddar cheese does not develop the large Swiss holes that are characteristic of Swiss cheese, because in the development of acid that occurs in the ripening of the milk, which is due to the growth of lactic acid bacteria, a condition is produced that is unfavorable to the development of gas-generating organisms.

In a limburger cheese, the lower temperature at which the curds are cooked results in the retention of large quantities of moisture, and changes the conditions within the cheese so as to

cause a very different kind of fermentation to take place from that which occurs in cheese of the cheddar type.

A. BACTERIAL FLORA OF MILK AS AFFECTED BY REMOVAL OF SUGAR.

On the hypothesis that a variation in the composition of milk would change the nature of the by-products produced as a result of bacterial development, experiments were conducted as follows:

Inasmuch as the lactic acid bacteria predominate in cheese, and are generally believed to exert the greatest influence on its character, and therefore on the production of flavor, it seemed probable that if the chief food of these organisms, the milk sugar, was removed, that the conditions would be so changed as to materially alter the nature of the by-products and possibly even the character of the flora itself.

In order to remove the milk sugar, milk was subjected to dialysis at a low temperature. This was done by placing the same in large parchment tubes immersed in running ice water. In about two days all trace of sugar had disappeared as shown by Fehling's test, likewise a large part of the ash. The casein under these conditions is not diminished, although of course it is materially diluted.

When such milks were removed and kept at room and incubator (37° C.) temperatures, the growth of the bacteria naturally present was very rapid, resulting without an exception in the production of putrefactive products instead of the lactic acid usually formed when milk is allowed to undergo a spontaneous change. These results were confirmed by numerous subsequent experiments. A test of these dialyzed milks for indol gave without exception positive results, and the marked fecal odor of these milks left no doubt as to the production of a putrefactive instead of the usual acid fermentation. This indicated that milk sugar either directly or indirectly prevented the milk from undergoing putrefactive changes, and explains why milk does not putrefy like other organic solutions rich in protein.

ADDITION OF SUGAR TO DIALYZED MILKS.

This hypothesis was verified by the addition of sugars (glucose and saccharose) to dialyzed milks. In this case the control dialyzed milk curdled in a few days with the production of a foul odor, the intensity of which was increased by incubation at higher temperatures, while those samples of the same milk to which these sugars had been added soured in two days with no disagreeable odor.

Not only was there this differentiation that was evident to sight and smell, but cultures made from such milks at the beginning of the experiment, and after a period of four days incubation showed a marked change in the relative proportions existing between different species of bacteria in the milks. The initial analysis of the dialyzed milk showed a considerable number of liquefying bacteria, but a predominant number of non-liquefiers. After incubation for four days the liquefiers had greatly increased in the control dialyzed cultures, while those to which sugar had been added showed many more of the non-liquefying, non-putrefactive type. From this experiment, it is evident that the presence or absence of sugar in milk exerts a marked effect on the character of the contained germ life. Where sugar is present, optimum conditions prevail for the development of acid bacteria; where absent, the putrefactive forms gain the ascendancy in such nitrogenous solutions as milk.

This principle, that sugar exerts an inhibiting effect on putrefaction of proteid matter, is further proven by the action of minute quantities in preventing the formation of indol in bacterial cultures. It has also been noted that sugar inhibits the production of proteolytic or digesting enzyms among certain bacteria (slow liquefiers on gelatin).

B. BACTERIAL FLORA AND FLAVOR OF CHEESE AS AFFECTED BY REMOVAL OF SUGAR.

The previous experiments with milk have demonstrated that the sugar prevents the putrefaction of the proteid compounds and this result led to a study of the effect which the removal of the sugar from milk has on the curing, and especially on the flavor of cheese.

Series I.—The sugar was removed from the curd by drawing the whey as early as possible and replacing the same with warm water. The curds were washed in some instances several times in order to more thoroughly remove the whey with its soluble products, and in no case showed any strings on the hot iron, indicating that no appreciable acid had been developed. In all 30 cheese (daisies and flats) were made in this manner and cured in a curing cellar at about 60°–65° F., with a control cheese for each set that was made according to the ordinary cheddar process.

These cheese were examined at intervals for several months, and within two weeks the cheese made from the washed curds began to be differentiated from the control cheddars. The washed cheese apparently cured more slowly and developed an unpleasant flavor which rapidly became more marked. In two months every cheese of the washed series was worthless, having a vile, rotten flavor, while the control cheese were of first quality. Where the cheese were washed a number of times the bad flavors were much more pronounced than where the curds were treated but a single time. After a lapse of a year, the washed cheese still retained their objectionable flavors, and in addition, all of them were badly mottled, due to a bleaching of the color of the cheese. The washed cheese apparently cured more slowly as determined by physical examination, but a chemical examination as to the amount of soluble nitrogen products showed no difference between the washed and the control cheddar series.

From these data it appears that the removal of the sugar markedly affects both the flavor and texture of the cheese. As with the milks in which sugar was removed by dialysis, the cheese made from washed curds developed a strong putrefactive flavor.

Series II–IV.—Several other series of cheese were made from washed curds and the same subjected to a more frequnt examination, both chemically and biologically. The results obtained were as follows:

TABLE I.— *Chemical by-products, number of bacteria, and quality of cheese made from normal milk and washed curds.*

		Per cent. of Total Nitrogen in Soluble and Amid Form at Different Ages.					
		One month.		Two months.		Four months.	
		Total soluble.	Amids.	Total soluble.	Amids.	Total soluble.	Amids.
Series II	Cheddar	19	4	25	7.3	30.5	18
	Washed	13	3	22.2	6.7	36.5	17
Series III	Cheddar	15.5	4	26.5	6 3	37.0	14
	Washed	15.8	3.9	22 2	5	47.1	25
Series IV	Cheddar ..	18.7	4.3	25.1	9.2	35,1	20
	Washed	15	3.6	21	11.2	37.3	21

		Bacteria per Gram at Different Ages.					
		One-half month.		One month.		One and two-thirds months.	
		Total.	Liquefiers.	Total.	Liquefiers.	Total.	Liquefiers.
Series II	Washed	209,200,000	Numerous	78,150,000	219,000	65,400,000	100,000
	Cheddar	41,248,000	Sparse ...	63,575,000	Sparse .	6,000,000	Few.
Series III	Washed	79,000,000	Numerous	95,252,000	713,000	72,900,000	Numerous
	Cheddar	70,960,000	Very few..	38,375,000	5,000	7,410,000	Very few.
Series IV	Washed	69,400,000	Very numerous..	65,600,000	Many.	29,900,000	192,000
	Cheddar	Not analyzed bacteriologically					

		Quality of Cheese as Shown by Scores at Different Ages.		
		One month.	Two months.	Four months.
Series II	Cheddar ...	F.[1] good; T.[2] firm; curing well.	F. clean, low; T. silky, close body.	F. slightly off; T. mealy.
	Washed	F. rank putrid; T. poor, open body, worthless.	F. rank, putrid; T. curdy, not broken down.	F. vile; T. curdy.
Series III	Cheddar	F. sl. off, T. curdy.	F. clean; T. silky, close body, curing well, marketable.	F. about the same as at two months.
	Washed	F. rank, putrid; T. curdy, no good ...	Spongy, not curing, putrid.	Apparently not curing; flavor vile; texture curdy.
Series IV	Cheddar	F. clean, low; T. silky, body close.	F. splendid; T. smooth, waxy, meaty body.	F. fair, sharp; T. sl. mealy, body close.
	Washed	F. bad, no good.	Huffed, open, putrid, curdy.	Ditto, two months.

[1] F = flavor. [2] T = texture.

An inspection of the above table shows that the nitrogen in soluble form is greater for the first two months in the cheddar than in the washed cheese. As the cheese increases in age this relation is reversed, the washed cheese at four months showing a materially larger amount of soluble nitrogenous products.

When the amids are compared, the difference between cheddar and washed cheese is less marked, although the same general relation as noted in the formation of total soluble products is to be observed in most cases. An explanation of this condition will be more readily understood after the bacterial history of the cheese is presented.

With reference to the bacterial content of these two types of cheese, the most striking characteristic to be noted is the relative increase of liquefying bacteria found in the washed cheese. This type of germ life in the cheddar cheese was always sparse, a condition that confirms all previous analytical work in this line. In cultures of the cheese made from washed curds, the most striking peculiarity is the presence of the liquefying bacteria as is shown in Figs. 8 and 9, which represent gelatin plate cultures made from normal and "washed" cheese.

While the proportion of liquefying to total number of bacteria would be very small, if expressed percentagely, still the appearance as presented in the cultures as shown in Fig. 43 is very striking. This seems to indicate beyond all question that the environment in the washed cheese is such as to facilitate the development of peptonizing forms. The fact that the cultures made from the washed cheese also contain a very large number of the non-liquefying type, indicates that the acid-producing and digesting bacteria can develop in the same habitat simultaneously, if the environmental conditions are favorable to both germs.

In the light of the bacterial history of the "washed" and normal cheese, an explanation can now be easily given for the variation in the rate of formation of the proteid by-products that occur at different stages of the ripening process. The more rapid peptonization of the casein in cheddar cheese, as shown by the increased amounts of soluble proteids present, is undoubtedly attributable to the fact that this type of cheese contained a larger

amount of digestive enzyms (galactase and pepsin), as the washing of the curd would to a considerable extent remove these ferments. But as the condition in the washed cheese permits the development of the digestive or liquefying bacteria, the soluble by-products formed as a result of the action of the enzyms which they secrete accumulate in the cheese and so increase the rate of digestion.

FIG. 42.—Gelatin plate culture made from normal cheese showing great preponderance of non-liquefying (lactic acid) bacteria.

With reference to the quality of these cheese, table I showing the scores made at varying ages, indicates without exception that the washed series were of much inferior quality, not only as to flavor and texture, but were also loose and open in body. These cheese were rank and putrid in flavor, and it is especially noteworthy that the texture was curdy, the cheese not breaking down physically, although the chemical analysis shows a larger amount of soluble decomposition products.

In striking contrast with these series were the results obtained in the case of the control cheddar cheese, which without exception were good throughout the whole period.

These confirmatory experiments indicate beyond question that the removal of the sugar seriously impairs the quality of the cheese as determined by flavor, texture and in all other ways, and that this removal permits the development of digesting bacteria in a way that does not occur in normal cheddar controls.

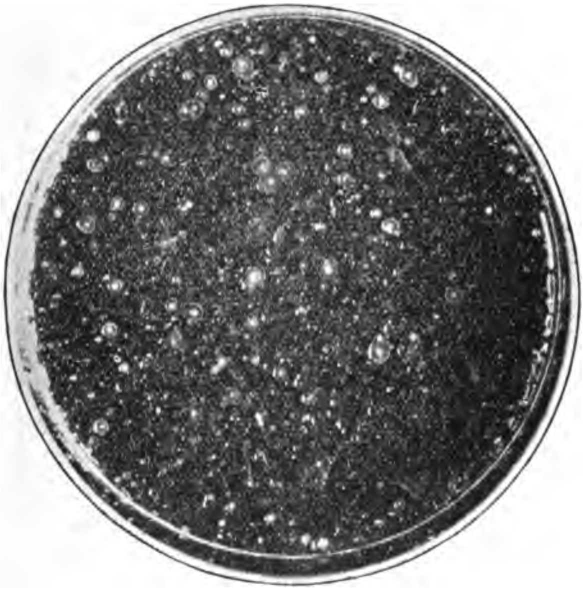


FIG. 43.—Gelatin plate culture made from "washed" cheese, showing development of liquefying bacteria which has been permitted through the removal of the milk sugar.

These results might be construed by the adherents of the theory that the ripening of cheese is due to the development of digesting or peptonizing bacteria, as supporting their claim; but when it is further considered that the quality of the cheese, as determined by flavor and texture, was most seriously impaired, and could not in any way be taken as representing the condition found in a normal cheese (at least those made after the cheddar method), this conclusion seems untenable.

C. ADDITION OF SUGAR TO WASHED CURDS.

To test the hypothesis regarding the influence of sugar on the flavor of cheese, experiments were then instituted in which sugar was added to the washed curds, in order to see if this substance

was the causal agent in preventing these undesirable changes. For this purpose glucose and cane sugar were used in varying amounts, and the cheese ripened at 60°–65° F. together with control cheese made from washed and normal curds.

Series I.—In these experiments the milk was divided, and from one portion, a cheddar cheese was made, while the balance of the curd was washed one or more times and then divided. To portions of this washed curd, cane sugar or glucose was added in the proportions of 1.25, 2 and 2.5 lbs. per 1,000 lbs. of milk.

Within two or three weeks the cheese made from the washed curds began to go off in flavor while the sugar series were clean in flavor, but slow in curing. This differentiation continued to become more and more marked until in a few months the "washed series" were adjudged worthless, while the "sugar series" continued to keep a fair to good flavor, but did not develop the same flavor as the cheddar controls.

After a year's curing the washed series showed a badly mottled condition, due to bleaching of color which was generally most pronounced on the inside of the cheese. The sugar series showed a variable condition. Those made with the smaller amounts of sugar were somewhat bleached, but not nearly so much as the cheese of the same date of the washed series. Where 2½ lbs. of sugar were used, the color was unchanged and was as good as the cheddar checks, although the sugar series appeared to ripen less rapidly than the cheddar controls.

With reference to flavors after this long period of ripening, the cheese to which the smaller amounts of sugar were added were somewhat better than the washed series, but in some cases had a vile flavor. Where 2 to 2.5 lbs. of sugar were added, the flavor was much improved, clean but somewhat sweet, but in no case equalled that of the cheddar checks.

From the above it seems that the addition of sugar prevents the development of the bad putrid flavors that occur when the curds are washed, and confirms the previous hypothesis that the sugar of milk is an important factor in preventing putrefactive changes in milk or cheese.

Series II–IV.—To further test the validity of this conclusion a new series of experiments were made which are detailed below.

Series II, III, IV were made on April 22, 25, and 29, 1901, respectively. The washed cheese reported in these series are the same as reported in table I in which the comparison of washed and normal cheddars was made. In the series here reported, varying amounts (1–3 lbs.) of different sugars (glucose, sucrose, lactose) were added to portions of the washed curds. In three cases in Series III and IV, sucrose was added to *cheddared* instead of washed curds, in order to show the influence of sugar in normal curds. These were examined more frequently during the earlier period of ripening; and chemical tests were made when the cheese were 1, 2 and 4 months old.

CHEMICAL EXAMINATIONS.

The results of the chemical studies on these several series of cheese are shown in table II.

TABLE II.—*Chemical decomposition products formed in cheese made from washed curds and those to which sugar has been added as shown by the per cent. of total nitrogen in soluble form and amids.*

	Am't sugar added per 1.000 lbs. of milk.	ONE MONTH.		TWO MONTHS.		FOUR MONTHS.	
		Total solu-ble	Am'ds.	Total solu-ble.	Am'ds.	Total solu-ble.	Am'ds.
SERIES II.							
Washed	0 lbs	13.0	3.0	22.2	6.7	36.5	17 0
Washed	1 lb. sucrose	15.0	3 0	24.0	5.2	38.2	15.0
Washed	2 lbs. sucrose	16 0	3.0	24.0	5.2	44.5	16.0
Washed	3 lbs. sucrose	15.0	3.0	23.6	5.4	41.6	15.0
Washed	2 lbs. lactose	16.0	3.0	23.6	5 2	40.4	15.0
Washed	3 lbs. lactose	15.0	3.0	22.0	5.0	40.2	15.0
SERIES III.							
Washed	0 lbs	15.8	3.9	22.2	5.0	47.1	25.0
Cheddar	2 lbs. sucrose	15.6	3.7	23.4	5.4	27.6	12.4
Washed	1 lb. lactose	15 6	3 8	22.6	5.4	34.2	17.0
Washed	2 lbs. lactose	15.9	3.6	22.5	5.0	36.0	16.0
Washed	3 lbs. lactose	15.5	3.8	21.7	5.2	36.0	17.0
SERIES IV.							
Washed	0 lbs	15.0	3.6	24.0	11.2	37.3	21.0
Cheddar	1 lb. sucrose	17.4	4.2	20.1	7.1	29.3	15.0
Cheddar	3 lbs. sucrose	18.8	4.0	21.0	7.0	22.5	10.0
Washed	1 lb. lactose	15.8	3.7	24.2	7.4	36.3	18.4
Washed	1 lb. glucose	16.0	3.7	24.3	7.4	39.0	21.0
Washed	2 lbs. glucose	15.9	3.6	23.3	7.8	39.0	20.6
Washed	3 lbs. glucose	16.1	3.7	23.7	8.8	38.0	19.0

In studying the chemical data here presented, it is necessary to compare cheese of the same series with each othr, as each lot was made from the same milk. In most cases the cheese made with the addition of sugar to the washed curd showed a slight increase in total soluble nitrogen over that formed in the washed curds and this increase was confined to the upper decomposition products that are characteristic of peptic action; but it is questionable from the chemical data at hand whether any significance is to be attached to this condition. Close comparison between these cheese can not readily be made because the amount of washing was not uniform, and hence a varying quantity of whey was removed.

In the three cases where sugar was added to cheddared curds, the chemical products showed marked difference from the results obtained with the washed curds treated with sugar. With increasing age, the total soluble nitrogen was considerably less than the sugar-washed series and the amid products strikingly diminished. It is possible that this is explicable by assuming that the soluble enzyms (galactase and pepsin) are retarded in their action by an increase in soluble solids, or that the lower per cent. of moisture in these cheese changed its rate of digestion. While we have no data on this point with reference to sugars, it is well known that salt, for instance, retards digestive action with both these enzyms.

BACTERIOLOGICAL EXAMINATIONS.

A bacteriological study of the washed and cheddar cheese showed that the removal of the sugar from the curd by washing resulted in a marked development of the liquefying bacteria. It will, therefore, be of interest to note the bacterial content of the cheese made from washed curds to which different sugars were added, particularly as to the relative presence of liquefying organisms. Table III shows the results obtained.

TABLE III.—*Number of liquefying bacteria per gram in washed cheese with and without addition of sugars.*

SERIES.	Treatment of curds.	LIQUEFYING BACTERIA PER GRAM AT DIFFERENT AGES.		
		Two weeks.	One month.	Two months.
II	Washed + 0 lbs.	Very numerous.	219,000	100,000
II	Washed + 3 lbs. lactose	Few	10,500	Disappeared.
II	Washed + 3 lbs. sucrose.....	Numerous......	10,000	Disappeared.
III	Washed + 0 lbs	Very numerous.	713,000	Many.
III	Washed + 3 lbs. lactose	Very few	8,000	Disappeared.
IV.......	Washed + 0 lbs	Very numerous.	....	192,000
IV.......	Washed + 1 lbs. lactose.	Few	Very few......	Disappeared.
IV.......	Washed + 3 lbs. glucose.....	Few	Very few......	Disappeared.

The addition of sugars to the washed curds changes the conditions within the cheese to such an extent as to render development of the liquefying forms practically impossible. In this respect the addition of the sugar to the washed curds restores the conditions that prevailed before this substance was removed by washing. A comparison of culture plates made from the washed curds and those to which sugar had again been added were almost as striking as those shown in Figs. 42 and 43, which represent the condition in normal cheddar cheese and washed cheese.

QUALITY OF CHEESE (FLAVOR AND TEXTURE).

When the quality of these cheese made from washed curds to which sugars had been added in varying amount was compared with the washed controls, it was noted that the sugar series were materially improved as to texture and never acquired the intense putrid odor that accompanied the washed controls. Where only one pound of sugar per 1,000 lbs. of milk was added, the improvement was often slight, but always noticeable in the earlier periods. Better results were obtained where larger amounts of sugar were added (2–3 lbs.), although it should be said that in no case were the cheese equal in flavor or texture to the cheddar cheese made from the same milk.

The addition of the sugar gave firmness to the curd, making a closer texture and restoring to the washed curd the translucent yellowish appearance that normally appears in ripening cheddar cheese. In all cases the improvement in texture was more

marked than in flavor. The cheese showed a tendency to stickiness which was more noticeable with an increase in amount of sugar used. Where sugar was added to the washed curds a sweetish flavor was sometimes apparent. This was most marked in the cases where sugar was added to normal cheddar curds.

The conclusion from these three series of experiments confirms that noted as a result of the work done in 1900, and indicates that the addition of sugar to the washed curds restores in part at least, the conditions that prevailed in normal cheddar cheese. When this conclusion is taken in connection with the results obtained when normal cheddar and washed cheese were compared, it seems to indicate that the types of bacteria that may develop in a cheese are closely related to the presence and amount of sugar which the cheese contain; that the liquefying, digesting organisms are able to thrive better when the sugar is removed, and that under these conditions putrid flavors are produced that are entirely different from those normally occurring in typical cheddar cheese. It is possible that the development of these liquefying forms and the appearance of the undesirable flavors noted are nothing more than mere coincidences, but when these two conditions are brought about through the removal of the sugar, and the normal conditions in large measure restored through the addition of sugar, it seems highly probable that the two phenomena are causally related.

The whole series of experiments not only with cheese but those made with dialyzed milk seem to harmonize perfectly and indicate that the type of bacteria that develop in milk and cheese is largely controlled by the sugar content. These results open up an interesting field as to the development of flavors and a study of these problems from the environmental point of view may result in widening our knowledge relating to the same.

CAUSES OPERATIVE IN THE FORMATION OF SILAGE.

(Second Paper.)

S. M. BABCOCK AND H. L. RUSSELL.

I. Relation of temperature produced, loss in weight and amount of gases evolved in a silo.

The work on silage problems during the last year, the results of which were presented in the Seventeenth Annual Report of this Station, was with reference to the causes operative in the formation of silage. The hypothesis was advanced at that time that the hitherto accepted explanation ascribing these changes to the action of bacteria was not in harmony with the experimental facts adduced, but that the phenomena obtained were explicable on the assumption that the changes which took place were inherent to the plant cell itself, and were largely the result of the respiratory activity of the protoplasm of the plant tissues. Not only does the direct respiration of the plant cell function in the production of the initial heat of silage, but this, combined with the intramolecular respiration of the cell which continues after the free oxygen is exhausted are leading factors in the formation of the peculiar properties of silage.

Our work during the current year has been continued along similar lines with the view of further testing the validity of the hypothesis then advanced. Experiments have been made the past season for the purpose of determining the relation of the heat evolved to the respiration (direct and intramolecular) of the plant cell itself as well as that of the extracellular organisms (bacteria and molds). For this two galvanized iron receptacles were employed, which were one and one-half feet in diameter

and four feet high, and had a capacity of approximately 200 pounds of cut corn. These were filled with cut field corn of average state of maturity and hermetically sealed. The pressure was relieved by means of a U tube connection with an oil trap. Long glass tubes sealed at the lower end were inserted through the center of the cover, and in these thermometers were placed to record the temperatures under conditions where air would not be admitted to the silage. Each receiver was placed upon carefully adjusted scales and left there during the whole course of the experiments. Observations were made daily as to the weight and the temperature as well as the temperature of the room.

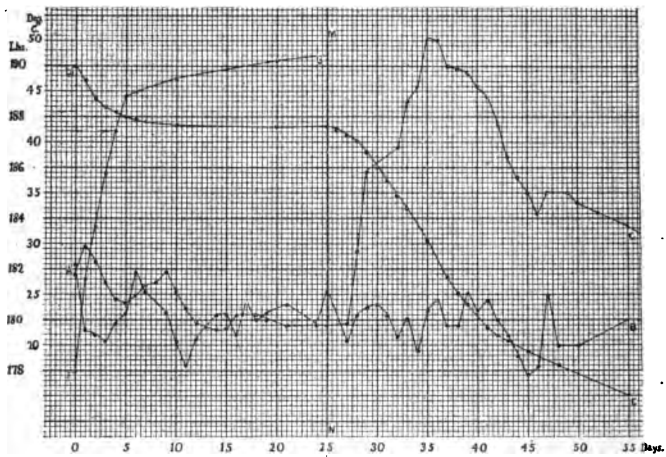


FIG. 44.—Diagram showing temperature changes, loss in weight, and rate of gas evolution. A, C, temperature curve of silage; A, B, room temperature; D, E, weight of silage; F, G, rate of gas evolution. Silo was opened on 25th day. Note variation in fermentative activity as expressed by rise in temperature and loss in weight after this date (right of line M, N).

The silos remained closed for twenty-five days. Copious evolution of gas began to occur within a few hours after sealing, and continued about ten days, after which the quantity evolved was gradually reduced to a minimum.

The observations as to temperature and weight are shown in Fig. 44, in which the average of the two determinations is made.

COURSE OF TEMPERATURE CHANGES.

It is to be noted that so far as temperature is concerned, the initial maximum was recorded on the first day after filling. After this the temperature fell off in a few days, but continued above the room temperature for a period of about twelve days, and after this period it fluctuated with the temperature of the room until the silos were opened on the twenty-fifth day. This nearly complete cessation of gas evolution and temperature changes indicates that the causes concerned in these changes had practically ceased to be operative. When opened the silage was found to be of good quality even on the very surface, there being no evidence of mold or bacterial decomposition. The aroma was also characteristic of first-class quality of silage. From this time the silos were left uncovered so as to permit of access of air in order to show the course of temperature changes incident to bacterial and mold growth. No appreciable rise occurred until about the third day (thermometer placed four inches from surface). Then the rise was rapid, and continued to increase for about ten days, reaching a maximum of about 50° C., or 20° above the initial heating. After the maximum period had passed, the temperature again fell, but never reached that of the room. The way in which these two maxima were developed indicates that they must have been produced by different causes. The secondary rise, coupled as it was with the evident development of organisms on the dead plant tissues required a certain period of incubation before the heat evolved as a result of the respiratory processes of the organisms was sufficient to become sensible.

The initial heat occurred within the first two days, being even marked in twenty-four hours. This must be due to the respiratory processes of cells already in existence, and could therefore only be ascribed to the living plant cells. Inasmuch as the free oxygen in the tissues and interspaces is rapidly exhausted by direct respiration, the heat to be noted for the several days following the initial rise is undoubtedly due to that produced by the intramolecular changes which occur before the cells die. Changes subsequent to this are simply incidental to room fluctuations.

LOSS IN WEIGHT OF SILAGE.

The change in weight of the silos was inconsequential after direct respiration ceased. The average loss for the first two days was 0.7 and 0.5 pounds per day. After this the loss rarely exceeded 0.1 pound per day, becoming practically constant when the temperature reached that of the room.

The weight of the silos after opening did not undergo any material change for a couple of days, but after this the loss was rapid, increasing to nearly a pound per day as the maximum temperature was reached, and then gradually diminishing to a few tenths of a pound per day. The loss after opening is of course due not only to gases evolved but to water evaporated as the surface was exposed.

The total loss before opening represents the unavoidable losses that cannot in any way be diminished as it is due to inherent processes of the cell. When measured percentagely the loss in this case was about one per cent. of total weight of silage. In practice it is rarely possible to exclude the air as thoroughly as in this case, and therefore the losses are generally greater, due not only to increased direct respiration but to the growth of mold and bacteria.

RATE OF GAS EVOLUTION IN SILO.

An independent experiment was made to determine the rate and amount of gas evolved. This was done by connecting a hermetically sealed glass carboy containing about forty pounds of cut corn with a gasometer containing water. The following table shows rate of formation and amount of gas produced:

TABLE I.—*Evolution of gas from 40 lbs. corn.*

Time (days.)	Amount of gas per day (liters).	Total gas (liters).	Time (days).	Amount of gas per day (liters).	Total gas (liters).
1	18.0	18	10	0.5	57.5
2	10.5	28.5	13	0.5	58.4
3	10.5	39	14	0.5	59.0
4	8.0	47	15	0.4	59.4
5	7 0	54	16	0.3	59.7
6	1.0	55*	17	0.3	60.0
7	0.8	55.8	20	0.3	60.9
8	0.7	56.5	23	0.3	61.8†
9	0.5	57			

* No oxygen in gas evolved at this date.
† 89 per cent. of CO_2 in gas evolved

These data are also charted on Fig. 44 in order that the gas evolution may be studied in relation to loss of weight and temperature. The fact that by far the larger proportion of gas evolved was thrown off in a period covered by the first five days is significant when considered with reference to the metabolic changes that occur in the tissues as a result of the activity of the plant cells themselves. If we assume that the gas evolved was CO_2, as has been shown by previous tests, making due allowance for absorption in the gasometer, the loss in weight due to the evolution of this gas would approximate one per cent., which is practically the same as determined by actual diminution in weight of silage in experimental silos.

These results as to temperature change, loss in weight, and gases evolved are only explicable on the common hypothesis that the normal changes are due to physiological processes (direct and intramolecular respiration) of the plant cells themselves; and that normally extracellular ferments (bacteria and molds) only function in a detrimental way when air finds access to the mass of plant tissues. This conclusion is the scientific foundation on which modern silo building is founded. If air is absolutely excluded from the silage, the inevitable losses are reduced to a minimum, and these are only exceeded when the construction of the silo is such as to admit air.

II. Further experiments, showing causal relation of plant cell activity to silage formation.

1. *Experiments with frozen corn.*—Experiments were made with immature cut corn and placed in a receiver, and then frozen immediately by means of a freezing mixture. These samples were then allowed to thaw and to one of them ether was added. This was done with the hope that immediate congelation of the plant tissues would destroy the cell activity and so prevent the formation of those by-products which are characteristic of silage. If, however, the silage changes went on in the dead protoplasmic matter as a result of bacterial action, then it would be possible under these conditions for these organisms to develop, because organisms of this type would not be entirely excluded by the freezing process. Samples so treated were opened after a period of twenty-two days and the following results noted:

The check sample, which had been ensiled in the usual way, had a distinctly silage aroma, which is characteristic of silage made from immature corn. The frozen sample had no trace of silage aroma, but a pronounced offensive odor as if incipient putrefaction had occurred. The portion to which ether had been added was also utterly devoid of silage odor, being simply preserved green corn.

A bacteriological examination showed organisms in considerable numbers in both samples, the predominating form in both cases being a small non-liquefying species. This fact is significant in considering whether the cause of silage changes is attributable to bacteria or plant cell activity. If attributable to bacteria of this type, the frozen corn should have made as good silage as the other.

A determination of acidity in these samples showed that 12.5 gms. from the check (normal silage) required 5.5 c. c. N-5 alkali to neutralize the same, while the frozen sample required 5 c. c. N-5 alkali, and the frozen sample, to which ether had been added, required only 2 c. c. This indicates that while practically the same amount of acidity was developed in the frozen sample as the result of bacterial growth, still this corn lacked

the essential characteristics that distinguish good silage from green corn tissues which have undergone bacterial fermentation.

It would appear from this that the immediate destruction of the life of the plant cells prevented the changes which characterize silage formation. Under these conditions all respiratory processes (intramolecular as well as direct) would be suspended at once; and hence, if these were causal factors in the production of silage, the tissues would not undergo the usual changes which characterize normal silage.

2. *Relation of aroma production to death of plant cells.*—This experiment consisted of ensiling a number of samples from the same lot of corn in small glass receivers which were hermetically sealed and provided with a U tube attachment to collect the gas evolved. These samples were to be opened successively at intervals of a few days to determine whether the aroma characteristic of silage would be recognized in the early stages before there could have been much opportunity for bacterial and fungus growth. The purpose of this experiment was to note the development of the aroma in relation to the death of the plant cell, which was indicated by the cessation of CO_2 evolution and the characteristic color changes which mark the death of vegetable cells. If the development of aroma took place before the death of the plant cells, it would seem that this would be strong proof of the relation of this essential silage change to the vital processes of the cell itself, especially when considered in the light of the experiments made on the development of temperature and gas evolution.

On September 24 late corn in a proper condition for silage was ensiled in six receivers. In these cases there was noted the first hour after sealing, a slight diminution in the volume of contained air due to the absorption of oxygen by the cut tissues (direct respiration). Within a few hours this pressure was reversed, showing that intramolecular processes had begun.

The first bottle was opened four days after filling. The leaves at the time showed a brownish olive color, but the stalks were wholly unchanged. Even at this early period there was a slight silage aroma, although the acidity of the tissues was not increased to the taste.

Seven days after sealing the second receiver was opened and the progressive discoloration of the tissues observed. In this case the leaves had wholly undergone the olive brown change and the stalks were discolored at the ends and nodes, but were still green in the middle of each cut piece. There was a distinct silage odor. A difference in the taste of the discolored and green portions of the stalk could be noted; the brownish tissues being slightly acid, while the juice of the green tissues was like that of fresh corn.

A third bottle was opened on October 6, twelve days after sealing. The tissues in this case were apparently dead, as determined by color changes, and CO_2 evolution had practically ceased in the manometer tube. This stage marks the end of plant cell activity, and if the characteristic aroma becomes intensified it must be as a result of post-mortem causes. This sample had a more marked silage odor than in the preceding cases.

The fourth sample was not opened until October 29, thirty-five days from the date of ensiling. No further change in the appearance of the silage could be noticed from that observed in the preceding sample. The silage in this case was of good quality as to aroma and taste although not sharply acid.

The last two receivers were opened on November 14, fifty-one days after ensiling. The silage was of good quality in each, and apparently had undergone no appreciable change as to aroma or taste.

The production of the characteristic aroma at the early stages noted, before the plant cells had died, is hardly compatible with the view that these changes are explicable on the theory that they are caused by the growth of organisms that must develop on the cells of the ensiled tissues. This observation adds probability to the conclusion already drawn that the internal processes of the living plant cell are the factors that inaugurate the series of changes that result in the production of typical silage.

ON THE INCREASED RESISTANCE OF BACTERIA IN MILK PASTEURIZED IN CONTACT WITH THE AIR.

H. L. RUSSELL AND E. G. HASTINGS.

In the work reported last year in the Seventeenth Annual Report[1] of this Experiment Station on the thermal death point of the tubercle bacillus in milk, it was shown, in confirmation of the view advanced by Smith[2] that the tubercle organism was more resistant in milk when heated in open than in closed vessels, the cause of this variation being attributed to the formation of the surface pellicle ("scalded layer"), which readily forms on milk when heated in open vessels to a temperature of about 140° F. (60° C.) or above. The importance of determining the reason why the destruction of bacteria in milk is subject to so much variation led us to institute a special series of experiments, the results of which are detailed below.

Having determined this variable relation with the tubercle bacillus, experiments were made with another bacterial species in order to see if consistent results could be obtained. For this purpose a micrococcus (Laby. No., R. 180) was chosen, which organism was originally isolated from pasteurized milk. This species possessed the unique property of retaining its vitality at temperatures considerably above 140° F. The extremely high thermal death point of this germ was an advantage in this work, inasmuch as it enabled us to exclude extraneous organisms that would naturally be present in the raw milk.

[1]Page 147.

[2]Theobald Smith, Journ. of Expt. Med., 4:217, 1899.

RELATION OF FLUID MEDIUM EMPLOYED TO THERMAL DEATH POINT DETERMINATIONS.

In the scientific determination of the temperature limit at which any organism loses its vitality, it is customary to expose the organism to be treated in a liquid medium, such as water or nutrient broth. The recommendation made by the Bacteriological Committee of the American Public Health Association[1] is that such determinations be made in nutrient broth of the standard degree of acidity (1.5%). Most of the thermal death work has been done in accordance with this suggestion, and it is therefore necessary at the outset to determine if the thermal death relation of an organism is the same in milk as it is in the standard nutrient broth.

Inasmuch as it is necessary to use sealed tubes in working with milk, exposures in other media were also made under similar conditions, because as yet unexplained differences were found when exposures were made in open and sealed containers.

THERMAL DEATH DETERMINATIONS IN VARIOUS LIQUIDS.

Nutrient bouillon.—The results obtained where exposure was made in nutrient bouillon are as follows:

TABLE I.— *Thermal death point determinations of resistant coccus (R. 180) in bouillon in sealed tubes (12 min. exposure).*

Temp. ° C.	Results of Tests. (+ = growth; — no growth.)			Temp. ° C.	Results of Tests. (+ = growth; — no growth.)		
	Series I.	Series II.	Series III.		Series I.	Series II.	Series III.
67	+	....	....	72	....	+	....
68	....	+	....	73	+	....	+
69	+	+	+	75	—	....	+
70	....	+	....	77	....	....	—
71	+	....	+				

The above results indicate that in standard bouillon this organism loses its vitality at about 75°–77° C.

[1]Processes recommended for the study of bacteria. Rept. of Bact. Com. of Amer. Public Health Ass'n, 1898, p. 34.

Skim milk.—In using milk as a medium in which to expose the organism, it is necessary to use the sealed tube to obtain comparative results, for if the determination is made in open tubes (as will be shown later) the disturbing factor of the surface pellicle seriously affects the results. A considerable number of tests were made under the standard conditions and the results obtained incorporated in Table II.

TABLE II.—*Thermal death point determinations of resistant coccus (R. 180) in milk in sealed tubes (12 min. exposure).*

Tem. °C	RESULTS OF DIFFERENT TESTS. (+ = growth; −, no growth.)			Temp. °C.	RESULTS OF DIFFERENT TESTS. (+ = growth; −, no growth).		
	Series I.	Series II.	Series III.		Series I.	Series II.	Series III.
67	+	....	....	73	....	+	+
68	+	....	....	74	....	+*	+
69	+	....	....	75	....	....	+*
70	+	....	+	76	....	−	+*
71	+	+	+	77	....	−	−
72	....	+	+	78	....	−	....

* NOTE. Positive results of tests marked with a star were only obtained after preliminary incubation of material heated before culture plates were prepared. This was done to enrich the culture so as to prevent misinterpretation of results due to insufficient seeding.

These results in milk correspond very well with those obtained in broth and indicate that the thermal death point of this organism is about 76° C.

Whey.—A few determinations were also made in whey, as it was thought that the possible influence of varying chemical reaction on the vitality of the organism might be less than where a totally different kind of liquid was used. The results of these tests shown in Table III indicate, however, practically the same thermal limits.

TABLE III.— *Thermal death determinations in whey (sealed tubes, 12 min. exposure).*

Temp. ° C.	Results of Test. (+ = growth. — no growth.)		Temp. ° C.	Results of Test. (+ = growth. — no growth.)	
	Series I.	Series II.		Series I.	Series II.
68	+	....	73	....	+
69	+	....	74	....	+
70	+	+	75	....	+
71	+	+	76	....	—
72	....	+			

In comparing the thermal death limits of this organism in different media when placed under entirely comparable conditions, it appears that practically the results are uniform—that where the exposure is made for fully ten minutes (12 minutes allowed in sealed tubes) at a temperature of about 76° C. the allowed in sealed tubes) at a temperature of about 76° C., the whey or bouillon in sealed tubes.

THERMAL DEATH LIMITS IN MILK IN OPEN AND CLOSED VESSELS.

Our previous experience with the tubercle bacillus[1] indicated that this organism is not destroyed as readily when milk is heated in open instead of closed containers. Theobald Smith has already called attention to this point and suggested that the increased resistance was due to the organism being imbedded in the surface pellicle of heated milk. The importance of this relation in the pasteurization of milk calls for a confirmation of this fact with other species of bacteria; accordingly experiments with organism R. 180 were also made.

Samples of milk heated in open vessels and sealed tubes were tested at different temperatures to see if any variation existed in the vitality of the contained bacteria. Samples were exposed at temperatures ranging from 63°–78° C. with the following results:

[1] 17 Rept. Wis. Expt. Sta., 1900, p. 163.

TABLE IV.— *Thermal death determinations of resistant coccus (R. 180) in closed and open containers.*

	Temperatures at which exposures were made for 12 minutes' duration.						
	63°	66°	69°	72°	75°	76°	78°
Sealed tubes.......	+	+		+[1]	+[1]	−	−
Open vessel........	+	+	+	+	+	+	+

[1] Positive results obtained only after preliminary incubation of the heated milk cultures.

From this it appears that the thermal death point of this organism is considerably higher in milk when the exposure is made in an open vessel than it is where the milk is kept in a sealed tube.

When the milk is heated in contact with the air to a temperature approximating or exceeding 60° C., there is formed on its surface a thin, cohesive layer or pellicle, and it seems reasonable to suppose that the increased resistance of the bacteria in milk so heated is due to this surface film, inasmuch as death of all cells takes place at lower temperatures in sealed tubes where such membranes do not form. This hypothesis is demonstrated by the following experiment, which has been repeated a large number of times under varying temperature conditions.

INFLUENCE OF SURFACE MEMBRANE ("SCALDED LAYER") ON VITALITY OF BACTERIA.

A sample of milk was copiously inoculated with this organism and then heated to a temperature of 76° C. In a very few minutes, at this temperature, the surface film forms, and after an exposure of ten minutes this membrane was removed with a sterile instrument and placed on the surface of an agar Petri culture that had previously been prepared. In forty-eight hours a perceptible growth was observable in the substance of the membrane and this continued to develop for several days, the colonies remaining separate and distinct.

This experiment was repeated a number of times and even

where the temperature was raised to 80–82° C, the membrane has shown the presence of developing organisms.

The appearance of such a membrane is shown in Figs. 45 and 46, preparations photographed from samples of milk heated to 78° and 80° C. In these surface pellicles the colonies are imbedded in the substance of the membrane, and are not merely on the surface, as can readily be shown by peeling off the pellicle after the contained organism has developed.

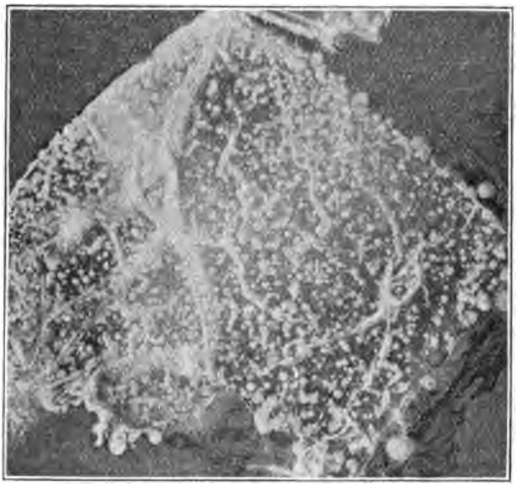


FIG. 45.—Surface membrane from milk heated to 78° C. for ten minutes and planted on surface of gelatin plate. Numerous colonies developing in membrane indicate that the bacteria in the milk were able to resist this temperature when developed in membrane.

RELATIVE VITALITY IN MILK OF BACTERIA IN SURFACE MEMBRANE AND BELOW.

In order to determine whether the increased resistance of bacteria in milk heated in open vessels was confined to the surface membrane or not, several experiments were made in which samples of milk were removed by siphoning off the deeper layers from below the surface film and cultures made therefrom. These were compared with cultures made from the surface membrane.

Samples of sterile milk, to which a culture of organism (R. 180) had been added, were heated for a period of twelve minutes in open beakers arranged with siphons, as described above.
above,

These samples were pasteurized at 74°, 76° and 80° C., and from each beaker portions of milk were withdrawn from below the surface by means of the sterile siphon, and the surface pellicle removed from each dish. Cultures made from these membranes showed numerous colonies in each instance, while the milk withdrawn from below remained sterile in all cases.

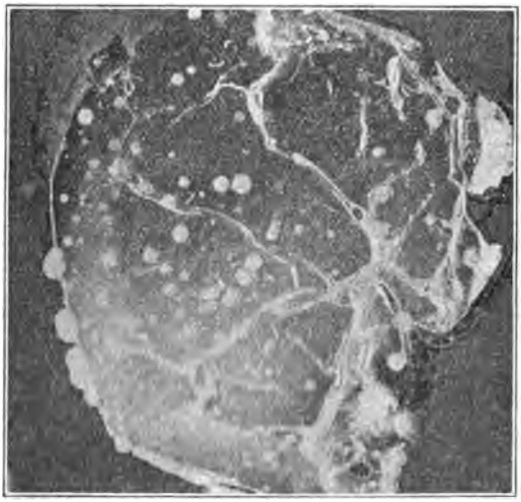


FIG. 46.—Surface membrane from milk heated to 80° C. for ten minutes. Note that a considerable number of colonies still persist at this temperature.

If, however, the samples taken from below the surface were incubated at 38° C. for several days and then plate cultures made therefrom, it was found that there was quite a large number of colonies developing on plates made from sample heated to 74°, only 3–4 colonies on 76° C. sample, while the one heated to 80° C. remained wholly sterile. This discrepancy in results is accounted for by the fact that all organisms are not killed at exactly the same temperature. Hence, when the thermal death point is very nearly reached so few organisms may remain in a living condition in the medium in which the thermal determination is made that ordinary cultures made direct from the heated sample may show no growth. If, however, such samples are first incubated in order to enrich them, evidences of bacterial development may be determined at temperatures somewhat higher than is possible by direct cultures.

In the above experiment the increased resistance of the organism in the surface membrane is indisputably shown.

This fact was also demonstrated in another way. After the removal of the first membrane at 80° C. the heating process was continued for an equal period of time at the same temperature. This permitted the formation of a second membrane which in the course of ten minutes was also removed. Cultures made from this remained wholly sterile, while if the first membrane was heated for the whole period of twenty minutes the organism persisted.

A repetition of the heat experiments was again made at somewhat higher temperatures, ranging from 72°–85° C. The results of these trials were as follows:

TABLE V.—*Results of thermal death point determinations in milk.*

	TEMPERATURES AT WHICH EXPOSURES WERE MADE FOR 10 MINUTES.			
	72° C.	76° C.	82° C.	85° C.
1. Surface pellicle	Numerous colonies.	Numerous colonies.	Few colonies.	None.
2. Milk withdrawn from below surface, three drops inoculated into each culture directly	Few colonies.	No growth	No growth	No growth
2. Above sample of milk incubated at 28° C. for six days before making cultures	Numerous colonies.	No growth	No growth	No growth

The conclusion from this and the foregoing experiment is that this organism is not killed in the surface pellicle at a temperature that is fatal to the germ when exposed in the deeper layers of the milk. In the surface membrane, the organism is capable of retaining its vitality when exposed for ten minutes at a temperature of 82° C., while it is destroyed in the milk below at a temperature about 6° C. lower.

CAUSE OF INCREASED RESISTANCE IN SURFACE PELLICLE.

Having determined experimentally the increased resistance of the organism tested in the surface pellicle, the question next arose as to the cause of this increased resistance.

Two possible explanations might be advanced as explanatory of this condition.

1. Diminished temperature of membrane at surface in comparison with the remainder of the milk.

2. Protection afforded to the bacteria by the nature of the membrane itself.

Where evaporation is taking place, as at the surface, the temperature is naturally reduced and it might be thought that this would influence the thermal death point. To eliminate this factor, the following experiment was performed:

After a sample of milk had been heated at 76° C. for ten minutes the membrane formed was removed and immediately placed in water at the same temperature. The difference in specific gravity caused the membrane to sink and the heating was continued for a period of 5-8 minutes under these conditions. Cultures showed that even where the membrane was thus submerged in water, and under conditnons that precluded evaporation, the vitality of the organism was not destroyed, although a considerable larger number of organisms were killed.

The elimination of this factor leaves the alternate hypothesis advanced as the most probable explanation of the phenomenon here discussed. Attempts have been made to produce an artificial membrane that was permeable to water, which when infected would give conditions comparable to those that obtain in the "scalded layer" in milk, but so far we have been unable to obtain satisfactory results. In all probability the increased resistance is due to the diminished water content of the scalded layer. Under these conditions the organism is exposed to an environment in which heat rigor does not occur as readily as it would in a liquid medium. An analogous phenomenon is to be noted in the marked variation which dry and moist heat exerts on the destruction of living protoplasm.

CONCLUSION.

The destruction of bacteria in milk by means of heat depends upon the conditions under which the exposure is made. Where milk is heated so as to permit of the formation of the surface pellicle ("scalded layer") the thermal death point of organisms is materially increased. This point has considerable bearing on the vitality of bacteria when subjected to various methods of preservation (sterilization and pasteurization) that have been applied to milk intended either for direct consumption or for butter making. Manifestly, the destruction of pathogenic or disease-producing bacteria is the question of most importance, and the work previously done by Theobald Smith, as well as ourselves, on the tubercle bacillus shows that this dangerous disease-producing species may retain its vitality in milk for a considerably longer period of time if conditions permit of the formation of the scalded layer on the surface of milk.

This relation of the surface membrane to the varying vitality of bacteria in milk is shown:

1. By growth of organisms in membrane at higher temperatures than in the milk below.

2. By sterility of membranes removed after initial membrane has once been formed.

The increased resistance of bacteria in the surface membrane is not entirely due to lowering of temperature at surface but appears to be affected by the nature of the enclosing membrane itself.

INFLUENCE OF THE RIGHT AMOUNT AND THE RIGHT DISTRIBUTION OF WATER IN CROP PRODUCTION.

F. H. KING.

The present year has been very unfavorable to large yields of almost all crops, both on account of the small amount of rainfall and its bad distribution. The actual conditions as regards rainfall are given below:

Rainfall for Madison during the growing season of 1901.

Date.	Rainfall in inches.	Rainfall in 10 day periods	Date.	Rainfall in inches.	Rainfall in 10 day periods	Date.	Rainfall in inches.	Rainfall in 10 day periods
April 6.....	.33	.33	May 31.....	.01	....	July 25.....	.38	....
15.....	.02	....	June 6	.15	.16	29.....	.69	1.07
17.....	.10	.12	11......	.44	....	Aug. 9.....	.12	....
May 3.....	.27	....	13......	.24	1 97	10.....	.05	.85
6, 7..	.88	.89	17......	1.29	....	15.....	.68	....
8, 9..	.24	....	22......	.07	....	19.....	.17	....
11.....	.05	.05	26	.15	.29	22, 23.	.05	.52
22.....	.77	....	29......	.07	....	26.....	.30	....
23, 21, 25.....	.61	1.43	30.	.06	....	Sept. 8.....	.41	....
			July 3......	.06	.12	9, 10	1.69	3.43
30.....	.05	....	18......	.41	.41	12,13,16	1.33	....

Comparing the rainfall of this year with that of last year, which was exceptionally favorable for corn and potatoes but poor for hay and small grains, the figures stand as in the table below:

Rainfall for 1900 and 1901 grouped in 10 day periods.

Date.	April.			May.			June		
Periods..........	1-10	10-20	20-30	30-10	10-20	20-30	30-9	9-19	19-29
1900..............	....	1.33	....	0.91	0.82	0.13	0.76	1.07	1.37
1901..............	0.33	0.12	....	0.89	0.05	1.43	0.16	1.97	0.29

Date.	July.			August.			September.		
Periods.........	29-9	9-19	19-29	29-8	8.18	18.28	28-7	7-17	17-27
1900..............	2.74	2.92	1.45	0.10	0.75	1.74	0.09	0.62	1.11
1901..............	0.12	0.41	1.07	....	0.85	0.52	....	3.43	... .

Comparing the two seasons it will be seen that the most marked difference between them is in the month of July, where each ten-day period of 1900 had more than an inch of rainfall, the total being 7.08 inches, while in 1901 the total was only 1.6 inches. In 1900 the serious dry period was during the last ten days of April and through the month of May, which made a short first crop of hay, and the first crop this year has been similarly shortened.

THE YIELD OF HAY.

In our soil moisture studies we have regularly kept the moisture on our plots of clover up to the best conditions for growth, so as to secure the full advantage of the clover on the soil. This year makes our sixth crop of clover and oat hay grown in rotation with corn and potatoes and the following are the yields this year:

Yield of hay under irrigation.

No. of plot	1	3	4	8
Crop	Oats and clover.	Oats and clover.	Clover.	Alfalfa.
	Tons.	Tons.	Tons.	Tons.
1st crop in tons per acre	3.153	3.483	2.626	2.108
2nd crop in tons per acre	1.770	1.272	1.034	1.280
3rd crop in tons per acre			1.240	1.074
4th crop in tons per acre				0.673
Total	4.923	4.755	4.900	5.135

The average yield per acre since the summer of 1896 in our systems of rotation has been as given below:

	Tons of hay per acre containing 15 per cent. moisture.
1896	4.044
1897	4.434
1898	4.031
1899	4.242
1900	4.581
1901	4.908
Average	4.373

This year there were 4.2 acres in hay from which we cut 20.59 tons, which we could this year have sold readily in the local market at $9.00 per ton. Without irrigation our yield could not have exceeded 1.5 tons per acre, which leaves the gain 3.4 tons per acre.

THE YIELDS OF CORN.

The yields of corn expressed as water-free dry matter and as silage has been as given below:

Yield of corn 1901.

	Irrigated.		Not Irrigated.	
	Dry matter lbs. per acre	As silage, tons per acre.	Dry matter, lbs. per acre.	As silage, tons per acre.
Plot 5	8,102	15.60	5,893	11.35
Plot 6	7,406	14.28	5,238	10.13
Average	7,754 5,565	14.94 10.74	5,565	10.74
Difference	2,189	4.20		

The irrigation has thus increased the silage at the rate of 4.2 tons per acre and the water-free dry matter 1.09 tons per acre. As our pump and engine have a capacity to easily handle twenty acres its saving might have been 80 tons of silage, or had the twenty acres been in hay, the saving would have been easily 60 tons since our actual gain on four acres was 3.4 tons per acre.

The yields of ear corn this year on plots 5 and 6 have been an average of the amounts given below:

	Irrigated, Bu. per acre.	Not irrigated, Bu. per acre.
Ear corn of 70 lbs. per bu. containing 15% moisture..	65.3	30.14

There has thus been a gain of 35.16 bushels of corn per acre due to better supply of water and, figured on twenty acres, the area the irrigation plant could have handled easily, the gain due to irrigation would have been 703.2 bushels. Our mean yield of corn silage containing 30 per cent. of dry matter, on irrigated ground, has been 16,688 tons per acre during the last eight years.

THE YIELD OF POTATOES.

The potatoes this year, as on previous ones, have been grown on clover sod manured at the rate of 18.6 tons per acre on plot 2 and 20 tons on plot 7. Our rotation has been corn, oats seeded to clover, clover and potatoes, with 20 loads of manure

per acre. The ground has thus been manured once in four years. Our yields this year have been:

	Irrigated.			Unirrigated.		
	Large bu. per acre.	Small bu. per acre.	Total bu. per acre.	Large bu. per acre.	Small bu. per acre.	Total bu. per acre.
Plot 2 after clover sod manured	398.24	19.36	417.6	194.65	16.42	211.07
Plot 7 after clover sod manured	326.05	21.62	347.67	185.37	17.80	203.17
Plot 10 after corn fallow in 1899	359.21	26.29	385.5	224.74	23.56	248.3
Average	361.17	22.42	383.59	201.59	19.26	220.85

From this table it appears that, with a mean yield of 201.59 bushels of merchantable potatoes per acre on ground not irrigated, holding the soil moisture up to standard conditions by irrigation increased the merchantable tubers 159.58 bushels per acre. These potatoes were hauled from the field and sold at 45 cents per bushel, but they were selling on the regular market at the time at 51 to 53 cents per bushel. As our irrigation plant could easily have handled twenty acres it would this year have increased the yield from such an area 3,191.6 bushels, making the gross earnings $1,436.22 more than the earnings without irrigation.

The mean yields of merchantable potatoes during our last six years of soil-moisture studies has been as given below:

	Irrigated, bu. per acre.	Not irrigated, bu. per acre.
Mean yield of merchantable tubers, 1896	301.0	210.8
Mean yield of merchantable tubers, 1897	333.6	212.3
Mean yield of merchantable tubers, 1898	178.8	163.8
Mean yield of merchantable tubers, 1899	307.3	174.9
Mean yield of merchantable tubers, 1900	328.2	343.4
Mean yield of merchantable tubers, 1901	361.2	201.6
Average for 6 years	301.7	217.8
Mean difference in favor of irrigation		83.9

It had been our purpose to carry this series of studies through ten years, so as to obtain a safe average upon which to base conclusions regarding the profits which might be expected from irrigation on fairly heavy soil in Wisconsin. As circumstances make it necessary for us to close the work here we shall draw our conclusions from the observations of seven years.

We have had in mind the management of about twenty acres as a combined dairy and potato farm where intensive farming shall be practiced in such a way as to maintain the fertility of the land without purchasing any fertilizers other than what would come through grain or meal bought for feed.

With twenty acres, of which six is occupied by farm buildings, a garden and a paddock for the cows in summer, there would be left fourteen acres for the four-year rotation we have been practicing and at the mean yields we have secured during the last seven to eight years the fourteen acres would produce each year:

58.415 tons of corn silage containing 30% dry matter.
12.675 tons of clover silage containing 30% dry matter.
14.556 tons of clover hay containing 85% dry matter.
10.056 tons of oat hay containing 85% dry matter.
1,055.6 bushels of merchantable potatoes.

It would require not less than sixty acres of land well managed to secure the above average product every year without irrigation in Wisconsin and the extra forty acres would more than pay for the irrigation plant, while the difference in the amount of labor would much more than compensate for the labor of irrigation.

It is not of course practicable nor desirable to irrigate all lands but there are thousands of cases where water can be applied cheaply where men now having small farms can make them the equivalent of much larger ones by a judicious use of water in irrigation.

INFLUENCE OF CLOSE PACKING OF CORN IN THE SILO ON THE UNAVOIDABLE LOSSES IN MAKING SILAGE.

F. H. KING.

In the annual report of this Station for 1900, p. 191, is given an account of an experiment to determine the influences of close and loose packing of corn on the unavoidable losses in making silage. This experiment was repeated this year under better conditions with the apparatus represented in Fig. 47.

On November 17, 1900, two one-quart and two pint glass milk bottles were filled with well-matured corn, cutting the stalks and ears into short sections and then splitting each section in two, putting one-half of each piece in the pint bottle and the other in the quart bottle until the pint bottle contained as much as could be pressed into it. In this way two pairs of bottles were filled in such a manner as to have closely duplicate material in each bottle but with the entangled air in the quart bottles more than that in the pint bottles.

After filling the bottles they were closed with corks covered with a heavy coat of sealing wax and containing a mercury valve, represented in the illustration, which prevented any air from entering on account of changes in temperature or barometric pressure, but which permitted the escape of gases evolved. With this arrangement the only losses in weight which could occur must be due to the escape of gaseous products and moisture in vapor form associated with the gases.

The weight of corn put into each of the four bottles is given below, together with the losses:

	1st Pair.		2nd Pair.	
	1 pint.	1 quart.	1 pint.	1 quart.
	Gms.	Gms.	Gms.	Gms.
Weight of corn at start	323.7	318.7	299.6	291.7
Loss of silage after 33 days	1.0	7.6	3.8	8.5
Per cent. of loss after 33 days	.31	2.38	1.27	2.91
Loss of silage after 303 days	2.4	10.4	5.6	12.0
Per cent. of loss after 303 days	.74	3.26	1.80	4.11

These results make it clear that close packing of the silage, which excludes at once as much of the entangled air as possible, reduces the unavoidable losses to an appreciable extent, the two quart cans, which contained the larger volume of entangled air, losing during 303 days 3.21 and 4.11 per cent. of the green weight, respectively, while the two closely packed cans lost only .74 and 1.87 per cent., the average loss being nearly three times as large with the loose packing as with the close packing.

FIG. 47. Apparatus used to determine the influence of close and loose packing on the losses in making silage.

The two pint bottles containing the closely packed corn came to a constant weight in eight and nine days, respectively, while the two loosely packed bottles continued to lose daily for twenty-eight and thirty days, more than three times as long.

After the rate of change had become small there appeared a periodicity in the rate of change of weight of the silage, very pronounced with the closely packed silage, the periods of no change in weight being much longer than the periods when changes did occur. This periodicity is evident in data reported last year and must be explained on a biological or chemical basis. It is certainly not related causally directly to either temperature or barometric changes.

THE GASES OF SILAGE.

In the last annual report, p. 195, an account is given of the measurement of silage gases given off from silage made in galvanized iron cylinders closed by soldering on metal covers so as to be thoroughly air tight except at the opening provided for leading off the gases for measurement. By passing the gases given off through a caustic soda solution to absorb the carbon dioxid, the silo No. 4, filled with immature corn, showed a mean ratio of 74.02 per cent. of CO_2 to 25.98 per cent. of other gases, and the more mature corn of silo No. 9 gave a ratio of 72.24 of CO_2 to 27.76 of other gases, while medium clover gave a mean ratio of 78.41 of CO_2 to 21.59 per cent. of the other gases. During the first few days of the ensiling process the ratio of CO_2 to other gases was found to be, in silo No. 9, for corn, 43.01 of CO_2 to 56.99 of other gases, and for medium clover the ratio was 47.10 of CO_2 to 52.90 of other gases.

These same silos have been kept in the laboratory undisturbed until the present time, and at my request Professor Whitson has made a number of analyses of the gases from these small sealed silos from time to time and also of those taken from the two silos at the University Farm. The results of these analyses are given in the table which follows:

Table showing the analyses of silage gases by Professor A. R. Whitson, using Hempel's apparatus.

ANALYSES OF CORN SILAGE.	CO_2	O.	H.	Residual gases.
No. 1. Small sealed métalic silo, No. 9, Feb. 26. Silage 230 days old	45.6	2.6	......	51.8
2. Silo in Dairy Barn, Feb. 28. Silage 171 days old	16.2	5.6	0.0	78 2
3. Silo in Dairy Barn, 2d sample, Feb. 28. Silage 171 days old	16.6	5.4	0.0	78.0
4. Small sealed metal silo No. 9, after filling with fresh air, March 15. Silage 245 days old	13.0	14.2	......	72.8
5. Small sealed metal silo No. 9, March 18, 3 days later	13.8	9 0	0.0	77 2
6. Small sealed metal silo, No. 9, March 30, 15 days after pumping in air	17.6	0.8	0.2	81.4
7. Small sealed metal silo, No. 9, April 15, 31 days after pumping in air	18.5	0.2	0.0	81.3
ANALYSES OF CLOVER SILAGE.				
8. Small sealed metal silo, No. 8, 17 An. Rept., Feb. 28. Silage 255 days old	34.2	1.6	3.0	61.2
9. Small sealed metal silo, No. 8, 17 An. Rept., March 2. Silage 257 days old	39.5	0.3	3.0	57.2
10. Small sealed metal silo, No 8, 17 An. Rept., March 15. Silage 270 days old	32.4	0.2	3 0	64.4
11. Small sealed metal silo, No. 8, 17 An. Rept., duplieate of March 15	30.6	0.0	3.0	66.4
12. Small sealed metal silo, No. 8, 17 An. Rept., Sept. 19, at bottom. Silage 458 days old	37.6	0.0	2.8	59.6
13. Small sealed metal silo, No. 8, 17 An. Rept., Sept. 19, at top, Silage 458 days old	32.2	1 0	1.6	0 65.2
14. Metal lined silo at farm, March 14, Silage 208 days old	15.2	0.2	......	84.6
15. Metal lined silo at farm, March 16. Silage 210 days old	18.8	0.2	0.0	81.0
16. Metal lined silo at farm, June 17. Silage 4 days old	82.0	0.1	3.1	14.8
17. Metal lined silo at farm, June 22. Silage 9 days old	73.6	0.2	3.4	22.8
18. Metal lined silo at farm, duplicate, same sample	73.8	0.1	3.6	23.5
19. Metal lined silo at farm, June 29. Silage 16 days old	59.0	0.0	2.9	38.1
20. Metal lined silo at farm, July 18. Silage 35 days old	23.0	0.0	1.2	75.8
21. Small metal silo of Bull. 83, very green clover leaves, 144 days old	67.2	3.0	10.6	19.2
22. Silo in Dairy Barn, residual gas examined for H., Sept. 18	......	0.4	0.2	....
23. Silo in Dairy Barn, reiidual gas, duplicate last	......	0.6	0.2	....
24. Silo in Dairy Barn, residual gas, examined for H., Sept. 20	......	0.3	0.1	....
25. Silo in Dairy Barn, resi0ual gas, duplicate of last	......	0.4	0.2	....

From these analyses and from the data presented in connection with the measurement of gaseous products from corn and clover silage given in the last annual report, it appears that:

First. In the earlier stages of the ensiling process carbon dioxid is the chief gaseous produce evolved.

Second. Hydrogen is generally and probably always to be found as a constituent of the gas of clover silage and there are some indications that it is to be found in that from corn silage also, but in too small quantities to be detected by ordinary gas analysis except in the residual gas.

Third. It appears quite probable also that the nitrogen found in silage gas is in part generated in the silo and not simply that

left over from the included air or carried in with that which may subsequently enter.

It should be stated in regard to the gas analyses made by Professor Whitson that the work was done in our Uniform Temperature Room in the sub-basement of the laboratory, lighted only by electricity, and where the only disturbing source of heat was that of the body of the operator.

The evidence in favor of nitrogen being one of the gases generated during the ensiling process comes chiefly from the data obtained from the three metal silos, No. 4, No. 9 and No. 8, which, after being filled, were closed with metal heads soldered in and proven to be gas-tight by forcing air into them under pressure. Two of these silos and the method of collecting and measuring the gas are represented in Fig. 24 of the last annual report.

The amount of space occupied by air in silo No. 8 was ascertained by filling the silo with water, introducing it at the bottom, September 20, 1901. Weighing this water gave the specific gravity for the clover silage of very nearly 1, and taking 1 as the specific gravity of the corn silage, the amount of air in each of the three silos at the commencement of the experiment was very close to the figures given below:

	Silo No. 4.	Silo No. 9.	Silo No. 8.
Contained air at start	4.279 cu. ft.	4.752 cu. ft.	4.764 cu. ft.

The total amounts of gas collected from the three silos were as follows:

	Silo No. 4 during 79 days.	Silo No. 9 during 56 days.	Silo No. 8 during 67 days.
Gas given off	20.10 cu. ft.	17.05 cu. ft.	15.7 cu. ft.

On the supposition that carbon dioxide was the only gas produced in these silos during the intervals above and that the nitrogen was carried out with the CO_2 in the proportion that it existed in the silage gas, starting with a ratio of 22 oxygen to 78 of nitrogen, the nitrogen should have been reduced by dilution with carbon dioxide produced after the escape of the amounts of gas above to the following per cents.:

	Silo No. 4.	Silo No. 9.	Silo No. 8.
Amount of N. remaining (per cent.)	2.88	6.14	7.52

The amounts of residual gas which were found near the close of this part of these experiments were as stated below:

	Silo No. 4. Mean between Aug. 20 & 31	Silo No. 9. Mean between July 5 & Aug. 5.	Silo No. 8. Mean between July 15 & Aug. 15.
Residual gas (per cent.)	29.30	25.51	20.27

If these results can be accepted they show an excess of residual gas over what should be expected, if only the residual nitrogen of the air originally in the silo were present, by the following amounts:

	Silo No. 4.	Silo No. 9.	Silo No. 8.
Excess of residual gas	26.42	19.37	13.75

To account for this excess of residual gas there appear to be but four possible explanations:

1. Diffusion of gas into and from the collecting reservoir through the water over which the gas was collected.
2. The failure to absorb all the CO_2 by the caustic soda.
3. Leaks in the three cylinders which permitted air to enter the silage.
4. Nitrogen in the gaseous form given off from the silage.

Considering the first supposition it is clear that if carbon dioxide coming from the silos was absorbed by the water and then diffused out into the air the nitrogen not doing so at an equal rate, the result would be to give too high a per cent. of nitrogen and make it appear that this gas was being evolved from the silage. But the weight of the measured gases which did escape from each of the silos is so nearly equal to the observed losses as shown by the scales in each case as to bar out this explanation, especially when it is observed that much of the water and other volatile products coming over with the gas were condensed in the collecting reservoirs, the water of which came to have a very strong odor and taste, which cannot be due to the carbon dioxide.

In the table below are given the losses from the three silos as shown by the scales and by the measured gases:

	Silo No. 4.	Silo No. 9.	Silo No. 8.
By weight on scales	2.4 lbs.	2.3 lbs.	2.1 lbs.
By weight of measured gases	2.24 lbs.	1.89 lbs.	1.78 lbs.

In computing the weight of the gases we have called the residual gas all nitrogen, which analysis requires, except for that from the clover silage, which contained a measurable but small amount of hydrogen.

When we came to open the three silos we found the appearance of all of the silage remarkably perfect and free from acid, the typical odor of "sweet silage" being unusually strong. The clover blossoms were not blackened and in some cases even retained a little of the pink color.

It is certainly not possible to explain the excess of nitrogen in the measured gas on the supposition that it got into the silo through leaks; first, because during the collecting period there was always outward pressure, and, second, because the quality and losses of the silage are against such a view. It may perhaps be urged that the excess of nitrogen diffused into the collecting reservoir through the water from the air outside, but when it is stated that the collecting bells are more than two feet long and have a diameter only one-half an inch less than their containers it does not appear possible that the diffusion could be rapid enough through so long and thin a column of water to account for the excess.

The large amount of nitrogen which Professor Whitson's analyses show to have been present in silo No. 9 and No. 8 later in their history, as given in his table on page —, is perhaps even stronger evidence that nitrogen is evolved in the silo under perfectly normal conditions when perfectly normal silage is produced. Referring to his results, it will be seen that he found in silo No. 9, 51.8 and 72.8 per cent. of residual gas and in silo No. 8, from 57.2 to 65.2 per cent., where it was all nitrogen except about 3 per cent. of hydrogen. This increase of nitrogen in the silage gas must either be due to a generation in the silo or to a leakage of air into the silo.

SILAGE AIR BECOMES RARIFIED.

It is true that after the stage of rapid generation of CO_2 has passed there come to be developed in the silo a negative pressure which tends to suck air into the interior. In our experiment with the pint and quart bottles the suctional effect at times

reached a full inch of mercury, and we have measured a pressure into silage in the silo of the Dairy barn of 9-16 of an inch. This is a fact of very great practical significance because it shows how important it is that the silo walls should be air-tight and that the silage should be closely packed, for otherwise this strong inward pressure will carry into the silage large volumes of air.

In the case of our experimental silos, however, no air could be drawn into them except from the gas reservoirs, but if nitrogen enough could have diffused through the water into the reservoirs it would have passed into the silos and given the results found by Professor Whitson. The good quality of the silage, however, appears to militate against this view.

SILAGE MAY BE EXPOSED TO AIR WITHOUT NOTABLE LOSS OF WEIGHT.

We have proven, however, that silage, after having passed the early stages of rapid change, may be exposed to air for a long time without suffering notable loss in weight. This was done in two experiments. The first of July, 1901, we disconnected silo No. 4 from the collecting reservoir and left the 3-16-inch brass tube, to which the rubber tube had been connected, wide open until September 23. We were led to do this by the notable breaking down of the silage which had been observed in some of our fruit-can experiments without much loss in weight.

When we came to open silo No. 4 we were astonished to find the corn silage unusually bright, wanting in acid, and the odor of sweet silage very marked without a trace of mold. Moreover a bushel of the silage was readily eaten by a cow which was being fed at the time on lawn grass and was not accustomed to silage. Indeed, so natural did this silage appear that with all my practical experience with silage I came very near disposing of it before I discovered that it was not normal. On tasting the silage I found it not only less acid than any I had ever examined but it had a decidedly abnormal taste. The silage was evidently spoiling, but it had stood nearly three months open to the air of the laboratory in the manner described without molding in the least and losing in weight only .3 pound, or .4 per cent., from May 15 to September 18.

The other experiment consisted in pumping air into silo No. 9 on March 15, forcing a large volume into the silo at the bottom and out at the top. Professor Whitson analyzed the gas from this silo several times after this treatment, with the results given below:

	CO_2.	O.	H.	Residual.
2 hours after filling with fresh air........	13.	14.2	....	72.8
3 days after filling with fresh air........	13.8	9.0		77.2
15 days after filling with fresh air..........	17.6	0.8	.20	81.4
31 days after filling with fresh air..........	18.5	0.2		81.3

During this interval a considerable volume of gas collected in the reservoir, but it was not measured.

On opening this silo September 23 only the slightest traces of mold were to be found, the silage had a beautiful green, fresh appearance and the normal "sweet silage" smell, but associated with this was a bad odor, not very strong, and the silage had acquired a disgusting taste.

CONCLUSIONS.

The true situation of the case appears to be this: We know that during the early stages of the ensiling process, carbon dioxide is given off in large volumes. Hydrogen is given off from normal clover silage in both the earlier and later stages and it is probably a constituent of the earlier gases from normal corn silage but produced only in small quantities. Nitrogen, other than that of the residual air, is likely to be proven to be a notable component of the gases from normal silage at all times. Water vapor and other volatile products escape with the gases of normal silage at all times, but their quantitative relations have not been sufficiently investigated to permit any statement as to how large the loss from these sources may be. Changes take place in normal silage which cannot be measured by either a loss of weight or the escape of gaseous or volatile products and these must be investigated before the changes in feeding value due to the ensiling process can be estimated and understood. The more loosely silage is packed in the silo and the larger the volume of entangled air the greater will be the unavoidable

losses. The more open and porous the silo walls are the larger will be the volume of air drawn into the silage by suction and forced in by wind-pressure and barometric changes. The larger losses near the upper surface of the silage, and especially at the sides, are measurably increased by what may be designated silage breathing. The loss from this source could certainly be reduced and possibly to a notable extent by providing a metal cover under the roof which, when the silo is filled and the doors closed, would leave the silo nearly air tight. Such an arrangement would reduce the breathing and thus lessen the loss.

14

DEVELOPMENT AND DISTRIBUTION OF NITRATES IN CULTIVATED FIELD SOILS.

F. H. KING AND A. R. WHITSON.

During the present year an effort has been made to continue the nitrate work of last season on all of the plots, the object being to learn what differences may result with differences of season and with a change of crop. Nitrate determinations have been made twice each month and always in each of the upper four feet, the samples being taken as described last year.

The work with the total soluble salts as indicated by Whitney's electrical method, has been discontinued because it was learned that while his method gave results which agreed fairly well with the gravimetric method for the surface foot of our soils, there was a wide disagreement when the second, third and fourth feet were compared, the gravimetric method giving more soluble salts with the sands and less with the clays than the electrical method did, while there was an approximate agreement with the loams which are intermediate in texture.

THE VARIATION OF NITRATES WITH THE SEASON AND WITH THE CROPS.

The total nitrates expressed in parts per million of the dry soil have been determined and will appear in a forthcoming bulletin giving the amounts found in each of the four feet of the ten plots on eleven dates, beginning with April 9, just as the frost went out of the ground, and ending with September 2.

If the nitrate content of the soil in the early spring for 1901 is compared with that of 1900, as given in Bulletin 85, pp. 18

and 19, it will be seen that there is a notable difference. This is brought out more clearly by combining the data as given below.

Table showing the mean nitrate content of soils, just as the frost is going out, on ground which the year before had been under corn, potatoes or clover, or oats seeded to clover. Amounts in parts per million of dry soil.

	Depth.	Soil under corn.	Soil under potatoes.	Soil under clover or oats seeded to clover.
Apr. 18, 1900	1st ft.	17.21	25.56	23.39
Apr. 9, 1901	1st ft.	48.60	81.03	14.72
Apr. 18, 1900	2nd ft.	10.14	13.76	18.33
Apr. 9, 1901	2nd ft.	24.57	57.95	7.54
Apr. 18, 1900	3rd ft.	10.31	32.56	9.47
Apr. 9, 1901	3rd ft.	15.97	32.94	4.23
Apr. 18, 1900	4th ft.	6.05	22.00	7.90
Apr. 9, 1901	4th ft.	15.22	14.21	3.06

From this table it appears that the surface foot is much richer in nitrates in the spring of 1901 than in that of 1900, except on the clover plots. The same statement is true for the second and third feet also, but in the fourth only the soil of the corn plots is richer in nitrates in 1901 than in the spring of 1900.

When a similar comparison is made for the month of September the results stand as given in the table below:

Table showing the mean nitrate content of soils in September on ground which has been under corn, potatoes, or clover, or else oats seeded to clover. Amounts in parts per million of dry soil.

Dry soil.	Depth.	Soil under corn.	Soil under potatoes.	Soil under clover or oats seeded to clover.
Aug. 30, 1900	1st ft.	8.55	38.29	20.81
Sept. 2, 1901	1st ft.	92.55	281.60	3.26
Aug. 30, 1900	2nd ft.	7.65	30.00	3.75
Sept. 2, 1901	2nd ft.	20.13	16.75	1.45
Aug. 30, 1900	3rd ft.	6.11	15.02	.79
Sept. 2, 1901	3rd ft.	14.93	12.70	2.95
Aug. 30, 1900	4th ft.	7.80	9.36	2.82
Sept. 2, 1901	4th ft.	9.87	5.60	4.54

At the beginning of September, this year, there was more than eleven times as much nitrates in the surface foot under corn than last year at the same date, and more than seven times as much under the potatoes, but under the clover the conditions are reversed, the nitrates being six times as strong in 1900. In every

foot the soil is richer in nitrates in September, 1901, under corn than in 1900, but under potatoes the conditions are reversed in the lower three feet, while under the clover the amounts are too small for the differences to have significance.

In the middle of the summer, July 1, the nitrates under the corn are less in 1901 than in 1900, except in the first foot. Under the potatoes they are less in each foot except the second in 1901; but under the clover there are more nitrates in 1901 in every foot except the surface.

If we compare the mean amount of nitrates under the three crops in 1900 with that of 1901, the results stand as given below:

Table showing the mean amount of nitrates in all plots in each foot and the total in the four feet for 1900 and 1901 in spring, mid-summer, and in fall.

	NITRATES, POUNDS PER ACRE.				Total nitrates.
	1st foot. Lbs.	2d foot. Lbs.	3d foot. Lbs.	4th foot. Lbs.	Lbs.
Mean for all plots, Apr. 18, 1900....	60.42	56.80	79.51	55.55	252.28
Mean for all plots, Apr. 9, 1901....	131.80	121.10	80.70	50.22	383.82
Difference	71.38	64.30	1.19	—5.33	131.54
Mean for all plots, July 2, 1900....	235.00	63.98	37.87	26.29	363.14
Mean for all plots, July 1, 1901....	318.40	54.34	27.43	22.30	422.47
Difference	83.40	—9.64	—10.44	—3.99	59.33
Mean for all plots, Aug. 30, 1900....	61.79	55.67	33.31	30.88	181.65
Mean for all plots, Sept. 2, 1901....	344.70	51.51	46.44	30.93	473.58
Difference	282.91	—4.16	13.13	—.05	291.93

Referring to this table it will be seen that at the beginning of September the excess of nitrates in the surface foot is 282.9 pounds per acre in 1901 over that of 1900 and there were 71 pounds more at the start in the spring.

Considering the total nitrates in the surface four feet of soil, there were 131.54 pounds more in the spring of 1901 than in 1900, and 291.93 pounds per acre more at the beginning of September. To what these differences may be due cannot be said with the data now available; they may have resulted from any one of three causes or a combination of them: (1) a longer surface evaporation and less percolation, thus bringing more nitrates into the surface four feet from below and permitting less to be lost by underdrainage; (2) a more rapid and deeper

nitrification owing to better aeration as the result of the smaller rainfall; (3) smaller yields of dry matter per acre, thus removing less of nitrates formed in the soil.

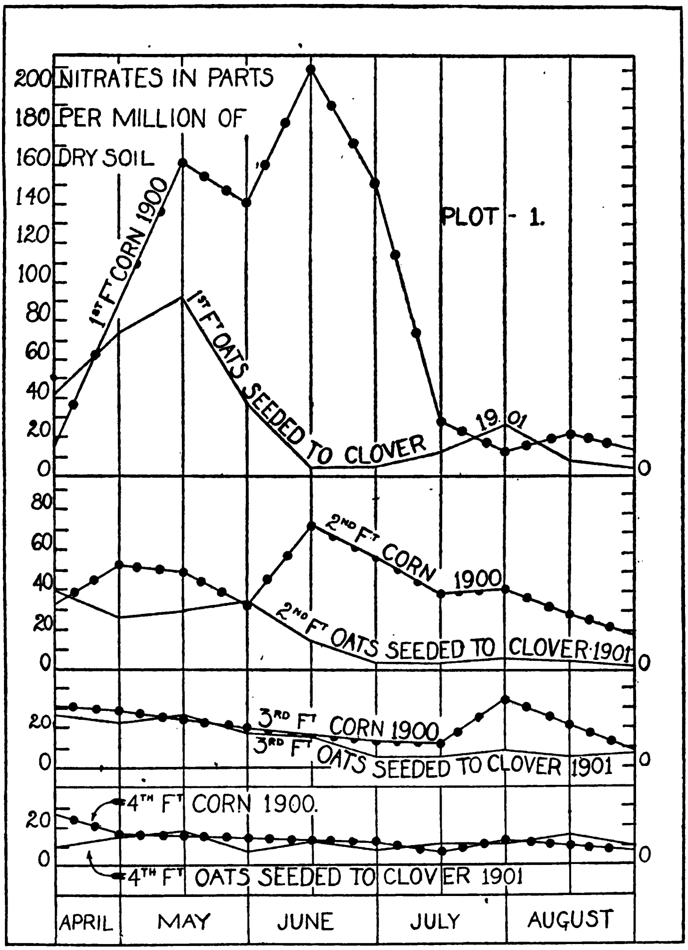


FIG. 43.—Showing changes in the amounts of nitrates in the soil of ground growing corn in 1900 and oats seed to clover in 1901.

The yields of dry matter this year have been, on the whole, where the samples were taken, smaller than last year, but the difference appears too small to explain the facts under consideration.

The difference in the nitrates of the several plots for 1900 and 1901 are represented graphically in Fig. 48, pp. 213, and Figs. 49 and 50 represent differences for individual plots: Fig. 49, where the crop has been the same both years, and Fig. 50, where the crop was different.

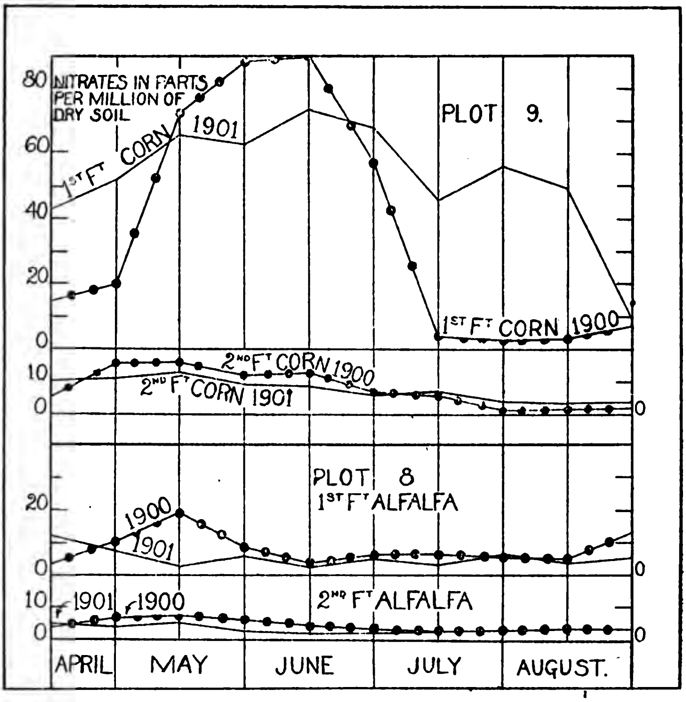


FIG. 49.—Showing changes in the amounts of nitrates in soil of ground growing corn two seasons.

VARIATIONS IN THE AMOUNTS OF NITRATES IN CULTIVATED PLANTS.

In connection with the nitrate studies of the soil this season some work has been done to ascertain the variation of the nitrates in the crops themselves growing upon the same soils at the same time. The nitrates in the plants have usually been determined on the day following the nitrate determination in the soil, taking the plants for sampling near the places where the soil samples were taken. The results found have been computed in two ways:

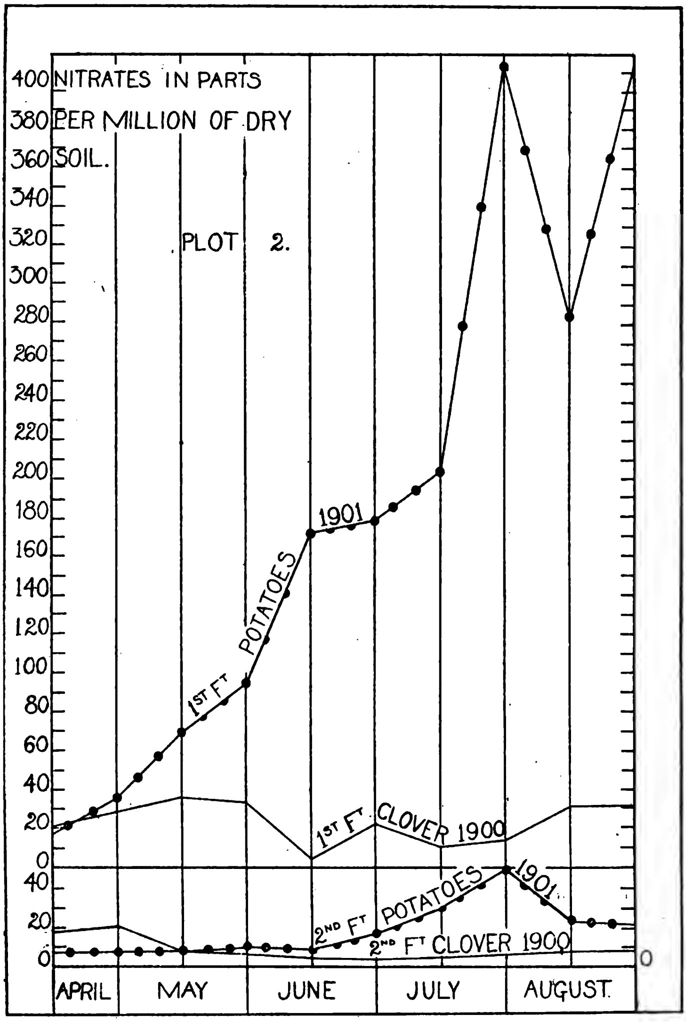


FIG. 50.—Showing changes in the amounts of nitrates in soil growing clover in 1900 and potatoes in 1901.

(1) as parts per million of the dry matter in the plant, and (2) as parts per million of the plant moisture. In some cases the nitrates have been determined in the stem and leaves separately and the results are given in the table which follows, together with the parts of nitrates per million found in the soil moisture of the surface foot:

Table giving the nitric nitrogen in plants expressed as calcium and magnesium nitrates in parts per million of the dry matter and of the plant moisture; together with the nitrates in the soil moisture of the surface foot.

	Nitrates.		June 7.	June 15.	July 2.	July 16.	August 2.	August 16.	Sept. 3.
Plot 5, corn.	In soil moisture..	....	......	780.3	744 2	1,255.5	1,292.0	1,176.1	1,544.5
		Leaves	......	....	3,192.0	183.7	538	437	344
	In plant moisture	....	......	3,313.8	....	....	....	....	....
		Stem ..	......	....	574.2	283.8	353.9	213.8	174.8
	In dry matter of plants ...	Leaves	......	2,925.4	1,650.2	651.2	170.1	119.3	750
		Stem ..	......	....	7,176.0	2,368.6	1,943.4	759.7	582.7
Plot 6, corn.	In soil moisture..	....	......	895.6	887.0	799.0	787.5	1,018.4	1,012.3
		Leaves	......	....	267.8	119.4	924	396	367
	In plant moisture	Stem ..	......	....	619.5	466.2	609 0	483.6	568.5
	In dry matter of plants......	Leaves	......	....	1,513.9	432.7	287.4	109.3	906
		Stem ..	.....	....	8,232.7	3,585.1	3,151.5	1,766.6	2,050.5
Plot 9, corn.	In soil moisture..	....	.....	355.7	369.8	272.5	421.1	346.4	111.9
		Leaves	.....	....	170.0	258	275	324	216
	In plant moisture	Stem ..	.....	199.2	261.9	603	323	406	393
	In dry matter of plants.......	Leaves	.....	....	851.4	864	816	195.7	538
		Stem ..	.....	1,578 0	2,829.6	438.1	142.4	141.7	123.0
Plot 2, potatoes.	In soil moisture..	....	......	872.1	1,060.2	1.061.7	2,185.3	1,461.2	....
		Leaves	......	....	612.0	760.1	532.5	576.3	761.6
	In plant moisture	Stem ..	.... .	....	1,100.5	1,134.7	....	....	....
	In dry matter of plants.......	Leaves	... .	....	3,886.2	4,307.6	3,662.9	3,479.0	4,922.5
		Stem .	.... .	....	3,750.0	10,813.7			
Plot 7, potatoes.	In soil moisture..	....	......	675.1	439.2	846 8	1,281.2	1,437.8	1,376.2
		Leaves	......	531.4	567.8	716.0	....	....	....
	In plant moisture	Stem ..	......	. ....	1,060.9	1,033.2	378.4	426.6	765.0
	In dry matter of plants.......	Leaves	......	5,060.4	3,730.9	3,887.9	2,230.2	2,513.4	4,113.4
		Stem ..	......	....	11,872.0	7,092.2	....	....	....
Plot 10, potatoes.	In soil moisture..	....	......	383.2	464.1	583.8	590.0	337.7	659.7
		Leaves	......	....	567.8	561.6	443.3	507.6	542.9
	In plant moisture	Stem ..	......	....	1,128.0	891.0	....	....	....
	In dry matter of plants.......	Leaves	......	....	3,731.7	2,364.0	2,792.7	3,017.5	2 915.9
		Stem ..	......	....	12,317.0	7,439.8	....	....	....
Plot 1, oats & clover.	In soil moisture..	....	......	23.8	49.8	....	145.1	42.2	23.1
	In plant moisture	St'ms & leaves	384	687.5	392	....	278	351	204
	In dry matter of plants.........	....	195.9	604.3	175.8	....	118.9	179.0	918
Plot 3, oats & clover.	In soil moisture..	....	......	15 9	37.1	....	62.5	21.5	5.9
	In plant moisture	St'ms & leaves	153.6	172.1	620.5	....	163	263	188
	In dry matter of plants.........	....	808	138.4	2,719	.. ...	628	106.5	807
Plot 4, clover.	In soil moisture.	....	......	87.5	32.5	27.2	77.1	43.2	21.9
	In plant moisture	St'ms & leaves	95	104.1	271	149	586	328	194
	In dry matter of plants.........	....	477	571	136 0	541	266.5	133.4	859
Plot 8, alfalfa.	In soil moisture..	....	......	19.9	29.7	24.7	47.3	19.1	26.0
	In plant moisture	St'ms & leaves	138.7	91	465	264	322	288	443
	In dry matter of plants.........	....	495	373	170.6	506	144 0	864	203.3

The method used for determining the nitric nitrogen in the plant tissues is as follows:

A sample of plants from the field was first chopped fine and mixed. From this mixture 20 grams were weighed out, placed in a wedgewood mortar, thoroughly crushed, and finally worked up with 250 c. c. of distilled water placed in the mortar. Twenty c. c. of this solution was drawn off into an evaporating dish

and heated over a water bath for a few minutes, to partly coagulate the organic matter. It was then allowed to cool, after which 6 to 8 drops of subacetate of lead, U. S. P., are added, with stirring to precipitate albuminoids. Then about one gram of powdered animal charcoal, previously digested in sulphuric acid and very thoroughly washed, is added, allowed to stand for an hour with occasional stirring and then filtered and washed with distilled water, making it finally up to 100 c. c.

The method of procuring a clear solution is that of A. Pagnoul, as described in Ann. Agron. 22 (1896), No. 10, pp. 485 to 590, slightly modified. An aliquot of this solution is then evaporated and treated as described in Bull. 85, p. 38.

To determine the moisture content of the sample for computation usually 100 grams of the cut material was dried.

As to the general accuracy of the method when applied to this class of problems we can only cite some tests or checks which have been made.

The first check was to ascertain how completely a known quantity of KNO_3 added to the distilled water in which the pulp was worked could be recovered. In the first trials the plant sample was worked up with distilled water and to this was added 10 c. c. of water containing 72.2 parts of KNO_3 per million.

The material used was a section of corn stems split in two halves, one-half being worked up with distilled water containing 72.2 parts of KNO_3 per million, thus securing two as closely duplicate samples as practicable. The results secured were:

	Readings by 1st observer.	2d observer.
Sample in distilled water + KNO_3	1,610	1,400
Sample in distilled water	1,300	1,310
Observed difference	110	90
Required difference	100	100

When these results are expressed percentagely they show in one case .708% too much and in the other .714% too little.

The second check on the method was to add a stronger solution of the KNO_3 containing 722 parts per million, working both sets in duplicate. The results stand:

	Readings by 1st observer	2d observer.
Sample in distilled water + KNO_3	3,356	3,364
Sample in distilled water	2,250	2,417
Observed difference	1,106	947
Required difference	1,000	1,000

Or, combining in the other way, the results stand:

Sample in distilled water + KNO_3	3,356	3,364
Sample in distilled water	2,417	2,250
Observed difference	939	1,114
Required difference	1,000	1,000

Expressing these results percentagely, the first grouping shows 3.16% too much and the other 1.57% too little; while the second grouping shows 1.81% too little in one case and 3.39% too much in the other.

As an example showing how closely work can be duplicated, the following case may be cited: On the evening of July 19, ten stalks of corn were cut from as many different hills along the margin of plot 5 and ten others in the same hills as nearly the size of those cut were marked to be cut in the morning of July 20, our object being to ascertain whether the method would show a change in the nitric nitrogen content during the night when the sunshine was absent. Each set of ten stalks was chopped fine and six samples taken from each of the two lots for nitric-nitrogen determinations and three samples for the determination of the dry matter. The electrical resistance of each solution was taken at the same time the other work was done and both sets of results are given in the table below:

Table showing the agreement of nitric nitrogen determinations in two independent field samples of corn and of 6 duplicates from each of the two samples, together with the electrical resistance. Nitric nitrogen is computed as calcium and magnesium nitrates in parts per million of dry matter.

SAMPLES TAKEN P. M., JULY 19.				SAMPLES TAKEN A. M., JULY 20.			
Per cent. of dry matter.	Colori-meter reading.	Nitrates parts per million.	Electrical resistance.	Per cent. of dry matter.	Colori-meter reading.	Nitrates parts per million.	Electrical resistance.
8.6	74 75	55,352 56,100	3,195 3,102	8.6	75 73	56,100 54,604	2,958 3,074
8.7	70 74	52,080 55,056	3,026 3,065	8.6	74 74	55,352 55,352	3,096 3,027
9.0	74 71	53,280 51,120	2,990 2,990	8.7	73 73	54,312 54,312	3,054 3,029

In these cases the sample was made to cover the lower measured foot of each stalk of corn.

Referring now to the table giving the nitrates in the crops at different stages of maturity it will be observed that in the case of the corn the nitrates, whether expressed in terms of the plant moisture or of the dry matter in the plant, have, in general, decreased with the degree of maturity in the crop; but with the potatoes or clover this relation is not so marked.

Where the determinations have been made in the leaves and stems separately the results show a greater concentration of nitrates in the stems, as would be expected if the nitrates are broken down in the leaves or converted into organic nitrogen compounds.

Everywhere the degree of concentration of nitrates in the sap of the plant stems is much higher than it is in the soil moisture. This appears very strange from the physical point of view and much more in harmony with the views formerly held by Bertholot and André, that nitrate of potash is continually formed in the stems of plants, but not accepted as correct by most authorities at present.

A SOURCE OF ERROR IN TOTAL NITROGEN DETERMINATIONS FOR PLANTS.

The large amounts of nitric nitrogen present in field crops, as shown by the colorimetric method described above, have led us to question whether the ordinary Kjeldahl method which we have been using for total nitrogen determinations in crops gives the data we supposed we were getting, namely, simply combined organic nitrogen. We had been following what appears to have been the general practice in this country in determining the total nitrogen in crops and did not anticipate that nitrates were likely to be present in sufficient quantity to make it necessary to take them into account in making determinations for total nitrogen.

When it was found that the crops under study contained such large quantities of nitrates it became evident that unless the ordinary Kjeldahl method included them we were not getting a true measure of the nitrogen removed from the soil; and since the ordinary Kjeldahl method is generally used to determine the total nitrogen and the amounts found are treated as organic nitrogen we supposed that the nitrates are not recovered when the method is used and it was concluded that we were removing more nitrogen from the soil with the crops than our analyses were indicating.

This led to testing the method and on making two duplicate sets of total nitrogen determinations for green oats in the milk, grown on soil very rich in nitrates, one by the ordinary and the other by the Kjeldahl method modified to include nitrates, the results given below were found:

		By the ordinary method.		By the modified method.
Total nitrogen found	1.	2.59 per cent.	1.	3.11 per cent.
Total nitrogen found	2.	2.69 per cent.	2.	3.13 per cent.
Average		2.64 per cent.		3.12 per cent.
Difference........................				.48 per cent.

The amount of nitric nitrogen shown to be present by the colorimetric method was .92 per cent., and subtracting .48 per cent. from this there appears to have been .44 per cent. of nitric nitrogen recovered by the ordinary method, which, were it treat-

ed as proteid nitrogen, would give 2.75 per cent. too much protein. Or, viewing the analyses from the standpoint of nitrogen removed from the soil the ordinary method would indicate an amount .48 per cent. too small, assuming that both the colorimetric and the modified methods gave reliable results.

Two similar duplicate sets of analyses were made of the stalks of corn when the ears were in the roasting stage, giving the results below:

		Ordinary method.		Modified method.
Total nitrogen found	1.	1.075 per cent.	1.	1.125 per cent.
Total nitrogen found	2.	1.060 per cent.	2.	1.135 per cent.
Average		1.067 per cent.		1.130 per cent.
Difference				.063 per cent.

The amount of nitric nitrogen present in the corn was .215 per cent. and subtracting .063 from this there appears to have been .152 per cent. of nitric nitrogen recovered by the ordinary method which, expressed as proteids, would be .95 per cent., or the analyses would have shown .063 per cent. too little nitrogen removed from the soil.

CHANGE IN THE AMOUNT OF NITRATES IN FIELD SOILS DURING THE WINTER.

In the last Annual Report and in Bulletin 85, p. 14, observations are cited showing that a field plot very rich in nitrates on August 22 came out the following May with a larger nitrate content than it had the preceding August, but it was pointed out that as it was not known how much nitrates may have been formed between August and the setting in of winter it was not possible to say how much loss from leeching may have occurred.

This season samples of soil were taken on April 9, as soon as the frost was out of the ground, and the nitrates determined for all of our plots for the purpose of comparison with the amounts found last fall, November 29, just as the ground was freezing permanently for the winter. The results of the two sets of observations are expressed graphically in Fig. 51 and in the table below:

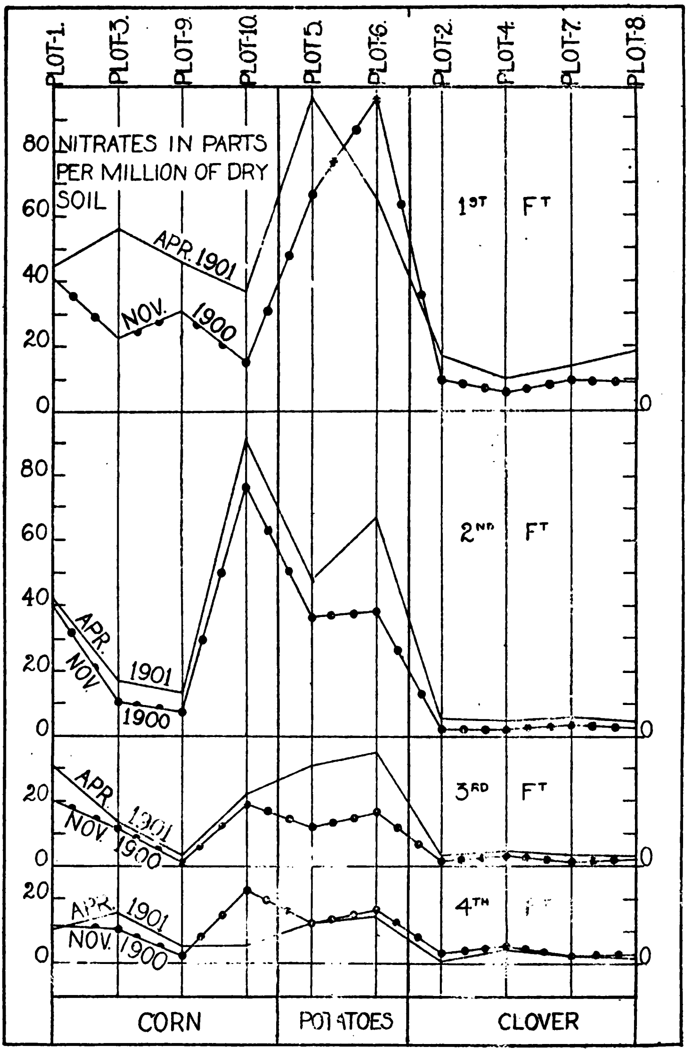


FIG. 51.—Showing changes in the amounts of nitrates in the soil between November 29, 1900, and April 9, 1901.

Table showing changes in the amount of nitrates in the surface, four feet of nine field plots between Nov. 29, 1900, and April 9, 1901, the period during which the ground was frozen.

Nov. 29	40.59	9.30	22.22	5.72	66.00	96.08	9.18	8.52	30.58
Apr. 9	44.02	17.22	55.87	10.05	96.61	65.45	13.59	18.00	45.90
Change	3.43	7.92	33.65	4.33	30.61	—30.63	4.41	9.48	15.32
Nov. 29.........	41.03	2.97	10.89	2.91	36.96	38.61	3.96	2 89	7 92
Apr. 9	42.70	5.80	17.56	5.14	48.10	67.80	5.75	5.05	13.46
Change......	1.67	2.83	6.67	2.23	11.14	29.19	1.79	2.19	5.54
Nov. 29	20.79	2.09	11 93	3.85	17.55	22.99	1.48	2.31	1.15
Apr. 9	31.02	3.81	13.28	5.50	30.13	35.75	3.95	3.20	3.67
Change	10.23	1.72	1.35	1.65	12.58	12.76	2.47	0.89	2.52
Nov. 29	11.77	1.60	10.39	4.84	12.64	14.30	2.58	2.80	3.08
Apr. 9	10.25	2.36	15.50	5.04	12.13	16.28	2.82	2.01	4.68
Change	—1.52	0.76	5.11	0.20	—0.51	1.98	0.24	—0.79	1.60

It will be seen from this table that there are but four cases in the nine plots and thirty-six determinations where there has been a loss of nitrates during the winter. On the contrary, there has been a notable gain of nitrates even in the fourth foot, the mean value being as stated below:

	1st ft.	2nd ft.	3rd ft.	4th ft.
Mean gain of nitrates, parts per million....	8.724	7.028	5.13	.7855
Mean gain of nitrates, lbs. per acre........	23.90	28.35	23.38	3.64

The observations thus indicate a total gain in the surface four feet of 79.27 pounds, equal to 14.41 pounds of nitric nitrogen per acre. There appear to be but two sources of nitrates which can have contributed to this observed increase in the soil. These are: 1st, nitrification in the soil, and 2nd, capillary movement of water upward, sweeping forward and bringing the nitrates from below the four feet with it.

Mr. J. O. Belz, p. —, has shown that in the surface six inches of soil from plot 4, nitrification may take place at the rate of .1594 parts per million of dry soil per twenty-four hours when the soil temperature is only a few degrees above freezing. Were such a rate of nitrification possible for the whole four feet the time required to produce the observed change would be 33.98 days. Since the whole interval of time covered 133 days, and since during the whole period the lower foot was continually above 32 degrees F., and during much of the time the second and third feet also, it does not appear impossible that the gain

may have been made in this way if only it is true that nitrification does go on at such depths in the soil.

It is quite likely, however, that the major part of the gain is to be explained on the basis of capillary movement of soil water. Observations made on the ground water under plot 2 at a depth of 7 to 8 feet showed a mean of 69.3 parts per million of nitrates present. On the basis of this amount there would be required 5.05 inches of water to be carried upward into the surface four feet to account for the observed increase in the soil.

During the winter months when the ground is frozen there is a considerable internal evaporation of soil moisture just below the frost zone, the moisture condensing and freezing in the soil above or escaping into the atmosphere. This loss of moisture by internal evaporation would tend to maintain a capillary movement upward to make good this loss, and with this would come whatever salts the water might carry in solution. We have measured the rate of evaporation from frozen soil in large cylinders out of doors and found it to be, between January 10 and March 12, at the rate of 1.243 inches per 100 days or 1.653 inches for the period of the experiment under consideration. When to this amount of water is added that which would be condensed in the frozen soil it does not seem improbable that 5.05 inches of water may have been carried from the deeper soil into the surface four feet above and with it not an inconsiderable amount of nitrates, perhaps enough even to account for the observed average increase. It appears to us, however, that both sources of nitrates referred to above have been responsible for the changes noted.

INFLUENCE OF TEMPERATURE ON THE RATE OF NITRIFICATION.

This experiment was conducted by Mr. J. O. Belz, a graduate of the University of Iowa, who has been taking Soil Physics as a major study in our laboratory the present year.

The soil used was the surface six inches of a clay loam taken from plot 4, April 11, before the frost was all out of the ground; and the object of the experiment was to ascertain the relative rates of nitrification under four nearly constant temperatures, these being near 32°, 50°, 70° and 90° F., respectively.

The method of conducting the experiment was as follows: From a large quantity of the field soil, thoroughly mixed in a tray out of doors, when the temperature was near 32°, about 2,000 grams were taken and put into a four quart tin pail to be placed in another receptacle surrounded by water at the desired temperature. The sample to be studied under the lowest temperature was surrounded by iced water. The second sample was placed in the large water reservoir in the basement of the laboratory; the third was placed in a store room near the center of the building surrounded by water in a tank containing about 6 cubic feet, while the fourth was placed in the laboratory in a similar tank of water, the temperature of which was controlled by a gas flame.

The nitric nitrogen content of the soil in each pail was determined by taking duplicate samples of 50 gms. each at the starting of the experiment and on each succeeding date, and much care was exercised not to have the soil samples exposed to the temperature of the laboratory more than a few moments before the nitrates were washed out in the formalin solution to arrest both nitrification and denitrification.

The soil was kept under conditions which permitted normal aeration and the moisture content of the soil was maintained nearly constant by the addition of water at the time the samples were taken, to restore that lost by evaporation during the interval.

The observations extended over a period of 27 days, from April 11 to May 8, and the results are given in the table below and are shown graphically in Fig. 52.

15

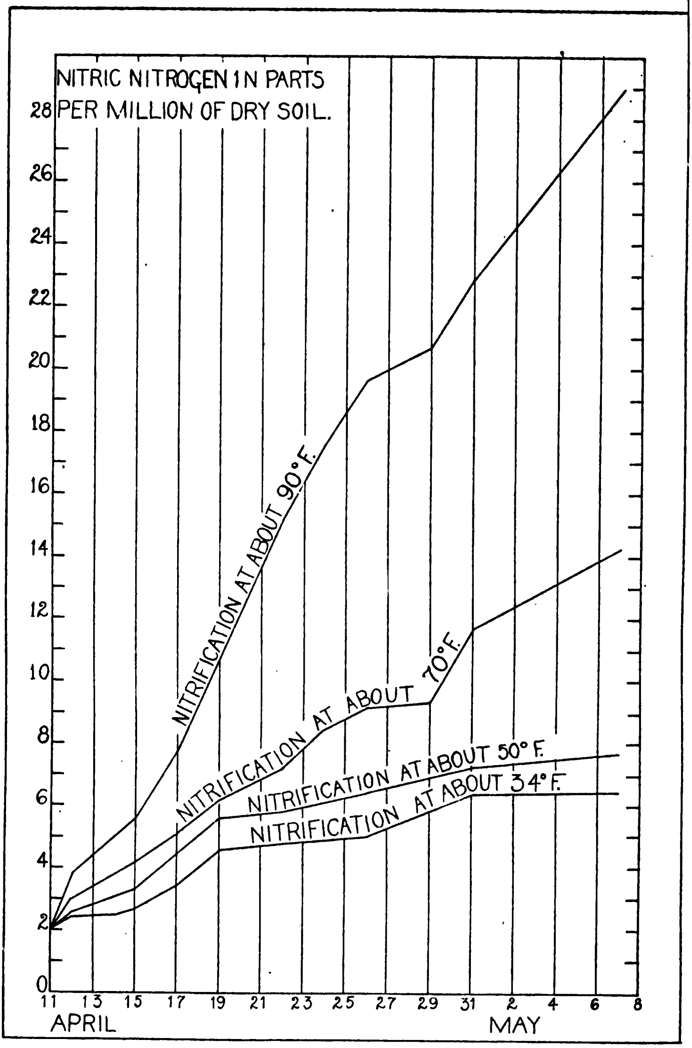


FIG. 52.—Showing the influence of temperature on the rate of nitrification in soils.

Table showing the rate of nitrification under different temperatures during an interval of 27 days.

Date.	Mean temp.	Nitric nitrogen in parts per million of dry soil.	Mean temp.	Nitric nitrogen in parts per million of dry soil	Mean temp.	Nitric nitrogen in parts per million of dry soil	Mean temp.	Nitric nitrogen in parts per million of dry soil.
April 11	....	2.2285	....	2.3035	....	2.3440	....	2.3175
12	34.1	2.3720	48.0	2.4795	68.7	2.9735	86.3	3.8230
15	38.5	2.6850	47.1	3.2655	66.6	4.2480	85.7	5.5685
17	41.5	3.4845	47.2	4.5470	63.45	5.1010	89.65	7.7000
19	33.5	4.5810	48.0	5.5705	61.5	6.1460	93.7	10.4600
22	33.0	4.8030	47.8	5.7505	63.6	7.2015	93.0	15.1600
24	34.0	4.8520	47.3	5.8660	65.15	8.4207	91.4	17.5500
26	33.0	5.0135	48.1	6.4480	70.25	9.2050	91.4	19.7600
29	33.9	5.4225	48.7	6.8245	74.00	9.2085	93.8	20.6705
May 1	33.8	6.3850	49.2	7.2315	75.85	11.6500	92.3	22.9800
8	34.0	6.5310	51.1	7.6995	76.8	14.1600	88.9	29.1200

The soil from which these data were obtained was in fairly good condition of fertility but had received no manure or other fertilizers for more than 5 years. At the lowest temperature the mean daily rate of nitrification was .1594 parts of nitric nitrogen per million of dry soil; or, expressed as calcium and magnesium nitrates, this is equivalent to .876 lbs. per million lbs. of dry soil. The surface 6 inches of an acre of this soil weighs about 1,370,000 lbs. and the above rate of increase would mean a production of 1.2 lbs. per day per acre and 120 lbs. in 100 days. The rate of nitrification at the highest temperature was 6.232 times more rapid than at the lowest temperature, the mean daily rates for the four temperatures being in parts per million of dry soil, as below:

At 35° F.	At 48° F.	At 68° F.	At 90° F.
.1593	.1999	.4376	.9927

and the amounts of nitrates which could be produced during 100 days in the surface six inches at the above rates would be per acre about

At 35° F.	At 48° F.	At 68° F.	At 90° F.
120 lbs.	150 lbs.	329 lbs.	747 lbs.

It must be clear from these results that a high soil temperature is a very important condition for the development of plant food, because it is in the form of nitrates that most plants are supposed to derive their supply of nitrogen from the soil.

It is commonly accepted as the result of the studies of other investigators that below a temperature of 41° F. nitrification either does not take place or it is at best very feeble; our observations are, in this respect, at variance with earlier studies. It is certain that our soil during the few minutes in which it was brought to the laboratory to weigh out the sample had an opportunity for the temperature of the surface portion to rise somewhat above the temperatures given in the table, but as the pail of soil was always returned at once to the metal case immersed in iced-water enclosed in a covered wooden tank, the number of minutes during the whole experiment when any portion of the soil could have been above 41° F., as the result of removal from the tank, certainly could not have aggregated a whole day during the period of 27 days the soil was under experiment. There were, however, three days, April 15, 16 and 17, when the ice got low and the thermometer reached 40.3°, 41.7° and 41.4°, but after this the thermometer showed a temperature below 34° F. on every day except one, when it registered 36.6°. These observations indicate, therefore, that considerable nitrification may go on even at as low a temperature as 35° F., and if this is true the late fall and even early winter may contribute not a little to the development of nitrates in our soils, in the lower part of the surface foot and the upper portion of the second foot.

INFLUENCE OF FALL PLOWING ON THE DEVELOPMENT OF NITRATES IN THE SOIL.

The present season some work has been done to ascertain the influence of fall plowing on the development of nitrates in the soil. Since fall plowing is a species of fallowing, in some of its effects it is important to know how influential it may be in increasing the soluble salts upon which crops feed. To determine this, samples of soil were taken, April 19, 1901, on closely adjacent ground which had been plowed Sept. 2, 1900, and that just plowed, and the amount of nitrates present determined in each of the surface four feet. Then again, on August 19, this summer, when another field was plowed and land adjacent was left unplowed, samples were taken on the margins of

both areas along lines about 8 feet apart and again Sept. 30, 42 days later, the nitrate content of both sets of samples being determined. The results of both sets of comparisons are given in the table below, computed to nitrates in lbs. per acre.

Table showing the influence of fall plowing on the development of nitrates in the soil.

Depth.	PLOWED.				NOT PLOWED.			
	August 19.		September 30.		August 19.		September 30.	
	Water, per cent.	Nitrates, lbs. per acre.	Water, per cent.	Nitrates, lbs. per acre.	Water, per cent.	Nitrates, lbs. per acre.	Water, per cent.	Nitrates, lbs. per acre.
0–6 in.	13.38	116.50	19.88	124.30	17.89	106.00	24.47	89.90
6–12 in.	7.13	....	19.17	....	10.81	....	21.43	....
12–24 in.	11.92	16.26	16.16	157.30	10.93	16.14	17.45	128.80
24–36 in.	12.99	28.94	14.10	24.11	13.76	17.50	14.42	24.70
36–48 in.	8.93	14.14	11.86	18.69	11.48	18.55	11.93	28.61
	After crop of peas.		After oats seeded to clover.		After oats seeded to clover.		After oats seeded to clover.	
0–12 in.	20.98	217.90	18.54	60.94	22.48	40.25	22.18	41.81
12–24 in.	23.08	257.40	15.00	79.99	22.84	16.26	18.33	15.57
24–36 in.	23.23	142.00	10.87	66.49	17.79	20.60	12.87	5.97
36–48 in.	14.75	76.46	5.70	27.50	8.11	20.68	8.52	0.00

If the total nitrates found in the plowed ground of Aug. 19 and Sept. 30 are compared, it will be seen that there has been a gain of 148.56 lbs. per acre during the 42 days. In the same way, comparing the total nitrates in the four feet of the unplowed ground of the same dates it will be seen that there has been a gain of 113.92 lbs. per acre, so that the effect of the plowing has been to increase the nitrates 34.64 lbs. per acre or about .8 of a pound per day.

Making the comparison in the lower section of the table, the total nitrates developed during the fall of 1900 and still retained April 13, 1901, under the plowed ground on which peas had grown was 693.76 lbs. per acre, while that found in the immediately adjacent ground, which was not plowed in the fall, contained only 97.89 lbs. per acre, or 595.87 lbs. less. It is quite certain, however, that a portion of this difference existed in the soil at the time it was plowed, Sept. 2, 1900, but how much can not be stated as the nitrates were not then determined.

In the remaining set of samples it is not likely that there was at the start any material difference because the two areas had

been under the same crop and were immediately adjacent to each other. The fall plowed ground showed the next spring 234.92 lbs. per acre, while that not plowed showed a total in the four feet of 63.35 or 171.57 lbs. per acre less. There were 89 days between the plowing of this ground in September and the freezing of the surface soil at the end of November, and the difference in nitrates calls for a more rapid gain on the fall-plowed ground of nearly 2 lbs. per acre per day, an amount more than double that shown by the study this fall. It should be said, however, that the ground this fall was very dry until near the middle of the period covered by the experiment.

A series of studies were also made of the differences in the rate of nitrification in the spring on ground which was plowed just before freezing up in the fall and in that not plowed. The observations were made on Randall Field which had been under corn during the summer of 1900 and on which the freezing of the ground stopped the plowing before it was completed. The samples were taken first in the spring on April 12, just after the frost went out and afterwards at intervals extending to April 29, five sets of determinations having been made. The results of the first and last sets are given in the table below; these determinations were made by Max W. King, who did the nitrate work in connection with irrigation studies at Stevens Point.

Table showing the rate of nitrification in the spring in soil plowed in the fall just as the ground was freezing the last of November, and in that immediately adjacent, not plowed.

	NITRATES IN LBS. PER ACRE.			
	1st foot.	2d foot.	3d foot.	4th foot.
Ground plowed, samples Apr. 12......	92.96	43.78	27.37	19.42
Ground plowed, samples Apr. 29......	151.20	95.55	39.14	42.08
Gain	59.24	51.77	11.77	22.66
Ground not plowed, samples Apr. 12..	111.2	28.55	14.55	6.41
Ground not plowed, samples Apr. 29..	217.0	99.86	21.59	17.09
Gain	105.8	71.31	7.04	11.68

The total nitrates shown in the plowed ground on April 12 was 183.53 lbs. per acre, while that in the unplowed ground was 160.71 lbs. per acre, a difference of 22.82 lbs. in favor of

the plowing; but on April 29 the nitrates on the unplowed ground has increased to 355.52 lbs. per acre, while that on the plowed ground contained only 327.97 lbs. or 27.55 lbs. per acre less. Accepting the figures as representing the facts it appears that the ground not plowed has increased in its nitrate content faster than the plowed ground did and at the rate of some 50.37 lbs. per acre. This is what should be expected if (1) nitrates are brought toward the surface by capillarity; (2) if there was greater evaporation from the ground not plowed than from that plowed, and (3) if the rate of nitrification was the same in both cases.

The soil water of the fourth foot, accepting the method and work as correct, contained 51.19 parts per million on April 12; at this rate the amount of water required to contain the 50.37 lbs. would be 985,900 lbs., and this expressed in acre-inches is 3.457. That is to say, in order to account for this increase of nitrates in the surface four feet by capillary rise from below that level the amount of water required to be brought up is 3.457 inches, supposing it to contain 51.19 parts per million.

The rate of capillary rise required to give this amount is .203 inches per day, equal to 1.18 lbs. per sq. ft. per day. This rate, although large, is not perhaps impossible under the conditions, because we have measured a capillary rise of water as rapid as 1 lb. per day per sq. ft. through four feet of fine sand under conditions where it is certain that it would have been more rapid if only the evaporation had been more rapid. We have also measured rates of evaporation from very wet field soils under field conditions which have much exceeded 1 lb. per sq. ft. per day.

At this stage of the investigation it appears probable that the increase of nitrates in the late fall plowing which took place after the frost went out, as well as in that not plowed, was due to differences in the amount of water brought up by capillarity from below the level of four feet, but that the larger amounts of nitrates which had accumulated under the early fall plowing as compared with the ground not plowed was due chiefly to more rapid nitrification, resulting from the better conditions maintained by the plowing.

STUDIES ON BLACK MARSH SOIL.

F. H. KING AND A. R. WHITSON.

Two lines of experiment on Black Marsh Soil have been carried on this year as follows:

Series I. To compare the crop on ground, from which the previous crop had been entirely removed, with that on ground where the previous crop had been worked into the soil.

Series II. To compare the effectiveness of potash salts with that of farm-yard manure and dried blood, as fertilizers on this soil.

SERIES I.

The Effect on a Crop of the Removal of the Previous Crop as Compared with Its Being Worked in as a Green Manure.

This study was made on the marsh soil in the 32 three-foot cylinders in the plant house. These cylinders are divided into two groups of 16 each. One group is filled with soil which had originally grown very poor crops, while the other is filled with soil which had grown better crops in the field.

On October 5, 1900, these cylinders were seeded, one-half of each of the above groups being seeded to oats and the other half to alfalfa.

On April 6, 1901, the crops on these cylinders were removed while still green, the oats being pulled up, removing part of the roots, while the alfalfa was cut off close to the ground, leaving the roots in the soil. The oats which had grown on eight cylinders was then chopped up and worked into the soil of the cylinders on which they grew. The other eight cylinders which had grown oats received no fertilizer, the oats being discarded.

This gave four cylinders of the poorer soil and four of the better soil which had received as a green manuring the oats which had grown on them and the same number of each kind of soil which received nothing.

In the case of the alfalfa cylinders, the material which had grown on two cylinders was chopped up and worked into the soil of one cylinder.

FIG. 53.—Showing the difference in the crop of corn grown on poor marsh soil where the previous crop had been removed (the two right hand bundles) and where the previous crop had been worked in as a green manure (the two left hand bundles).

This gave four cylinders of the poorer and four of the better soil which received as a green manuring twice the amount of alfalfa that had grown on them and equal numbers which received nothing.

This green material was not weighed, but was a heavy crop. On April 11th, all the cylinders were planted to corn, four hills to each cylinder.

On July 17th the corn was cut, grouped for each treatment and photographed. See, Figs. 53 and 54.

FIG. 54.—Showing the difference in the crop of corn growing on better marsh soil, wher the previous crop had been removed and where it had been worked in as a green mae nure.

After having dried in the air of a room for three months, the corn fodder was weighed, giving results as follows:

Table showing the weight in lbs. per acre of air-dry corn fodder grown on marsh soil the previous crop of which had been removed and on that the previous crop of which had been worked into the soil.

PREVIOUS CROP....................	OATS.		Alfalfa.	
Treatment.	Crop removed.	Crop worked in.	Crop removed.	Crop worked in.
Cylinders of poor soil..............	1,663	10,303	2,924	6,991
Clyinders of better soil............	4,682	9,700	8,345	11,425

From the above table and from the figures it will be seen that this treatment has had a very marked effect on the yield of corn. The poorer soil is affected much more than the better soil and the cylinders which had grown oats are affected much more than those which had grown alfalfa.

These differences cannot be due to lack of available nitrogen in the soil, since determinations of the nitrates in all of the cylinders made a few days before the crop was removed showed several times the amount which has been found in the soil on which heavy crops of corn were growing in the field.

The indications are that one or more of the mineral elements were present in but limited amounts, and in this respect the experiment is in harmony with those reported in bulletin No. 80, page 31, and the annual report of 1900, page 197, in which the addition of potassium was shown to be very beneficial.

SERIES II.

The Relative Effectiveness of Potash as Compared with Farmyard Manure and Dried Blood as a Fertilizer on Marsh Soil.

This study was made on the fields of the Experiment Station farm on which the experiment of 1900 on the effectiveness of different potash salts was conducted.

There are two fields, a north field and a south field. Each field was sub-divided into plots to be planted with five rows of corn each. On the north field one plot was treated with potassium sulphate at the rate of 263 lbs. per acre, one plot with dried blood at the rate of 555 lbs. per acre and a third plot with fresh cow manure at the rate of twenty loads per acre.

On the south side three plots were treated with muriate of potash at the rate of 171 lbs. per acre, dried blood at the rate of 277.5 lbs. per acre and fresh cow manure at the rate of 20 loads per acre, respectively. All fertilizers were applied broadcast and harrowed in.

The plots which were fertilized were separated from each other and from the border of the field by equal plots which received no fertilizer. Corn was planted on all the plots May 28th.

On Sept. 25–27 the corn was husked and samples dried to determine the amount of water-free ear-corn.

The dry weights of the crops of the two blank plots adjoining each fertilized plot are averaged to get the weight with which to compare the weight of the crop of the fertilized plots. The results are given in the table following:

Table showing the number of bushels per acre of corn on fertilized and unfertilized plots of marsh soil.

NORTH FIELD.

Treatment	Potassium sulphate	Blank.	Dried blood.	Blank.	Manure.	Blank.
Bu per acre ..	48.1	35.6	42.8	35.7	53.2	37.7

SOUTH FIELD.

Treatment	Potassium chloride.	Blank.	Dried blood.	Blank.	Manure.	Blank.
Bu. per acre ..	62.9	62.9	63.5	60.3	71.5	61.3

When this data is expressed as per cent. of increase due to each fertilizer it stands as follows: On the north field, potassium sulphate, 34.4 per cent.; dried blood, 20.1 per cent.; manure, 29.2 per cent. On the south field, muriate of potash, 0.0 per cent.; dried blood, 5.3 per cent.; manure, 16.7 per cent.

FIELD EXPERIMENTS WITH GRAIN AND FORAGE PLANTS.

R. A. MOORE.

NOTE.—The station will not be able to make any general distribution of seeds this year as the supply on hand will be needed for other experiments.

I. VARIETY TESTS OF GRAINS.

The experiments for 1901 with seed grains were largely a continuation of those carried on during 1899 and 1900. The object sought is to grow and develop by selection and improved methods of cultivation choice varieties of grain and disseminate the same throughout the state. Care is taken to note and devise methods of eradication or correction of diseases and defects to which farm crops are subject.

The drought existing throughout southern Wisconsin affected the experimental work on grains by hastening the ripening period and lessening the yield of grain and straw per acre, as well as the weight per measured bushel. All varieties of grain ripened about ten days earlier than last season, and the yield was decreased nearly one-half.

The experimental plots are located on the same tract of land used last season for the variety tests of grains and comprises about six acres, which is divided into plots containing one-twentieth of an acre each.

Larger plots of land were used for growing varieties that had been tested for two or more years and which possessed characteristics that warranted growing them in larger quantities.

The different varieties of grain tested, the source of original seed, yields of grain and straw with other data are given in the following table:

Yield of straw and grain in variety tests of cereals, 1901.

NAME OF VARIETY.	Wisconsin No.	Origin of seed.	When received.	Date of sowing.	Seed per acre (by weight).		Growing period.	YIELD PER ACRE.		Weight of grain per bushel.
								Grain (by weight).	Straw.	
OATS.				1901.	Bu.	Pks.	Days.	Bu.	Tons.	Lbs.
Siberian	1	Ontario, Canada	1899	Apr. 23	3		87	37	1.	33
Daubenney	2	Ontario, Canada	1899	Apr. 26	3		81	33	.8	32
Poland White	3	Ontario, Canada	1899	Apr. 24	3		84	21.3	.6	32
Swedish	4	U. S. Dept. Agri. No. 2,788	1899	Apr. 25	3		84	38.1	1.	37
Tobolsk	6	U. S. Dept. Agri., No. 2,800	1899	Apr. 25	3		84	31.3	.9	35
Early Gothland	8	Minn. Exp. Sta., No. 26	1900	Apr. 25	3		86	46.8	1.2	34
Minnesota	9	Minn. Exp. Sta., No. 35	1900	Apr. 25	3		85	35.6	.7	35
Big 4	12	Salzer Seed Co	1900	Apr. 24	3		84	31 3	8	28
Bow of Promise	13	Salzer Seed Co	1900	Apr. 24	3		87	28 1	....	38
Lincoln	15	Minn. Exp. Sta., No. 23	1900	Apr. 25	3		87	33.1	1.	35
Monarch	16	Minn. Exp. Sta., No. 77	1900	Apr. 24	3		84	35.6	1.3	30
White Bedford	17	Minn. Exp. Sta., No. 85	1900	Apr. 24	3		83	40.6	.9	32
Archangel	18	Minn. Exp. Sta., No. 29	1900	Apr. 25	3		83	36.2	1.	35
White Wonder	21	Minn. Exp. Sta., No. 21	1900	Apr 25	3		85	25	.9	30
Improved Ligowa	22	Minn. Exp. Sta., No 6	1900	Apr. 24	3		87	25	.8	38
Russian	24	U. S. Dept. Agri., No 2,963	1899	Apr. 25	3		87	23.1	1.1	36
Silver Mine	25	Columbia County, Wis	1900	Apr. 25	3		87	35	.9	34
Iowa Silver Mine	26	Iowa Exp. Station	1900	Apr. 25	3		84	26.2	.6	29
Red Rust Proof	29	Iowa Exp Station	1900	Apr. 24	3		83	34.3	.6	34
Early Champion	33	Iowa Exp. Station	1900	Apr. 25	3		83	31.8	.6	30
Wisconsin Wonder	34	Jefferson Co., Wis	1900	Apr. 21	3		85	34.3	.7	33
Finland Black	35	U. S. Dept. Agri., No. 5,513	1901	Apr. 26	3		82	12.5	1.	28
American Banner	36	Fond du Lac, Wis.	1901	Apr. 29	3		85	25	1 2	30
Swede	37	U. S. Dept. Agri., No. 5,471	1901	....	3		83	32.5	.8	36
Finland	38	U. S. Dept. Agri.. No. 5,032	1901	....	3		92	9.3	.4	31
BARLEY.										
Beardless	51	Salzer Seed Co	1900	Apr. 25	1	2	77	39.2	.7	44
Silver King	53	Salzer Seed Co	1900	Apr. 25	1	2	77	42.2	.8	44
Mandshury	54	Ontario, Canada	1899	Apr. 25	1	2	77	33	.5	43
Oderbrucker	55	Ontario, Canada	1899	Apr. 25	1	2	77	43.7	1.3	45
Kinna Kulla	57	Ontario, Canada	1899	Apr. 25	1	2	77	24.1	.5	43
Select Altamura	68	U. S. Dept. of Agri	1899	Apr. 25	1	2	81	28.3	.7	42
Mandscheuri	59	Minn. Exp. Sta, No. 105	1900	Apr. 25	1	2	77	43.7	.7	42

French Chevalier	60	Minn. Exp. Sta., No. 15	1900	Apr. 25	1	2	81	23.3	.6	46
Golden Queen	61	Minn. Exp. Sta., No. 100	1900	Apr. 25	1	2	77	33.3	.5	42
Mandscheuri	62	Wis. Exp. Station	1899	Apr. 25	1	2	77	43.7	.8	44
Mandshury	64	Minn. Exp. Sta., No. 6	1900	Apr. 25	1	2	77	32.1	.8	41
Giant White Hulless	65	Salzer Seed Co.	1900	Apr. 25	1	2	79	19	.5	60
Svanshals	66	U. S. Dept. Agri., No. 5,474	1900	Apr. 26	1	2	81	48.3	.8	46
Altamura	67	U. S. Dept. Agri., No. 4,340	1901	Apr. 26	1	2	Did not mature..	....	....	....
Princess Koru	68	U. S. Dept. Agri., No. 5,472	1901	Apr. 26	1	2	81	37.1	1.4	45
Hannah	69	U. S. Dept. Agri., No. 5,793	1901	Apr. 26	1	2	81	45.2	2.1	50
EMMER.										
Russian	122	U. S. Dept. Agri., No. 2,959	1899	Apr. 26	1	2	84	29	.7	61
PEAS.										
Oddfellow	141	Ontario, Canada	1899	Apr. 26	2		86	10	.3	63
Early Britain	142	Ontario, Canada	1899	Apr. 26	2		86	7.6	.4	53
Prussian Blue	143	Ontario, Canada	1899	Apr. 26	2		86	8	.4	53
WINTER WHEAT.				1900.						
Turkish Red	111	U. S. Dept. Agri.	1900	Sept. 5	1	3	Harvested July 1....	32.3	1.3	62
King's Early	112	U. S. Dept. Agri., No. 5,079	1900	Sept. 5	1	3	Winter killed....	....	....	....
WINTER RYE.										
Petkus	132	U. S. Dept. Agri., No. 5,058	1900	Sept. 5	1	3	Harvested July 1....	37.8	1.5	57
Schlansted	133	U. S. Dept. Agri.	1900	Sept. 5	1	3	Harvested July 1....	36.7	1.5	56
VETCH.										
Russian	200	U. S. Dept. Agri	1899	Sept. 5	1	1	Harvested July 5....	2.5	....	61

Oats.—The Swedish oats (Wisconsin No. 4), procured from the United States Department of Agriculture in 1899, showed such special commendable characteristics that it was thought advisable to grow all possible from the grain raised from the original seed. Geo. Schneider of Middleton, Dane county, co-operated with the writer and sowed the said oats in accordance with directions given. Twenty-three bushels 6 pounds were sown on 7.6 acres, which yielded approximately 40 bushels per acre. This is considered an excellent yield, since common varieties averaged about 30 bushels per acre in the portion of the state affected by drought.

FIG. 55.—Wisconsin No. 4. Swedish Oats.

During the past three seasons thirty-eight varieties of oats have been tested on the experimental plots to determine the variety most satisfactory for Wisconsin conditions. The yield per acre of straw and grain, the weight of grain per measured bushel, the thickness of hull, the susceptibility to lodge, and variety most subject to rust, etc., have been carefully noted.

The two varieties most satisfactory in the three years' tests are the Wisconsin No. 4 (Swedish oats. See Fig. 55), and the Wisconsin No. 1 (Siberian oats). Some other varieties tested have given a larger yield of grain for a single year, but had

inferior characteristics which would not warrant them being ranked with the two above named varieties until further trial is made.

The Swedish oats originated in Sweden and was introduced into Finland and Russia. Mr. M. A. Carleton, of the United States Division of Vegetable Physiology and Pathology, visited Russia in 1898 and secured for the Section of Seed and Plant Introduction about twenty bushels of the seed, which was distributed to the various Experiment Stations of the United States. The writer obtained sufficient to sow one-tenth of an acre in 1899 and was so well pleased with it that several plots were sown the following year, some of which yielded at the rate of 80 bushels to the acre and averaged 64½. This year 7½ acres were sown to this variety, which yielded 306 bushels (40.8 bushels per acre).

The Siberian oats were imported by the Agricultural College at Guelph, Ont., from Russia in 1889, and is the variety of oats that has given the best general satisfaction, both at Guelph Agricultural College and in co-operative experiments throughout Ontario, Canada, out of 227 varieties tested during the past thirteen years.

In 1899 a sufficient amount of the Siberian oats were secured from the Ontario Station to sow one-fortieth of an acre and this year a plot of four-fifths of an acre gave a yield of 33.8 bushels, weighing 35 pounds per measured bushel. The one-twentieth of an acre plot of the same variety was somewhat less in yield per acre, and is given in the preceding table. The oats are so satisfactory that the entire amount will be sown the coming spring and distribution of that raised next year will be made throughout the state as far as the supply will admit.

The Wisconsin No. 8 Early Gothland and No. 17 White Bedford gave excellent yields, and promise well for the future. These varieties were secured from the Minnesota Experiment Station in 1900 and were grown for the first time on the experimental plots last year.

The Wisconsin Wonder, American Banner, Finland and Swede oats (Wis. No. 37) were tested for the first time on the experimental plots this year.

Barley.—Sixteen varieties of barley were tested on the experimental plots this year with varying results. The Mandscheuri, Nos. 59 and 62; Oderbrucker, No. 55, and Silver King, No. 53, gave the best yields and were the most satisfactory of the six-rowed barleys grown. The Oderbrucker and Mandscheuri No. 62 have been grown for three successive years and have given excellent satisfaction.

The Mandscheuri barley was first introduced into Ontario by the Agricultural College at Guelph, from Russia, and the Wisconsin Station received its original supply therefrom. It has been grown with great satisfaction in this state and Ontario and is noted for its early maturing qualities, its strength of straw, its remarkable yields of grain and weight per measured bushel compared with other varieties.

The Oderbrucker (No. 55), which is a close second, was imported from Germany by Guelph Agricultural College in 1889, and a sample was obtained from Canada by the Wisconsin Experiment Station in 1899. In yield of grain and weight per measured bushel it is the equal of the Mandscheuri, but is excelled by the latter in stiffness of straw, which prevents lodging to a considerable degree. Of the newer varieties tested Salzer's Silver King (No. 53) is proving very satisfactory and is showing all the characteristics of the Mandscheuri.

The two-rowed varieties tested have not been satisfactory; the yield being from ten to fifteen bushels less per acre than that of the six-rowed varieties and the straw being so frail that most plots lodged greatly.

Three new varieties of two-rowed barley secured from the United States Government last winter, were grown for the first time on the experimental plots the past season. These varieties, Wisconsin Nos. 66, 68, and 69, gave remarkable yields of grain, and further developments will be carefully noted.

The Hulless barley tested seemed to make a good growth in the early part of the season, but the straw is weak and as soon as fairly headed it lodges badly, preventing the proper maturing of the grain and making it difficult to harvest.

The Beardless barley, Wisconsin No. 51, has given fairly good yields during the past two seasons; like the Hulless, the

straw is weak, but as it grows much shorter it does not lodge so badly and allows the grain to mature better.

There seems no advantage in growing these latter varieties of barley, even if the yield is equal to that of the bearded varieties, especially if the grain is grown for market, as comparatively a small amount is raised, and no regular market price therefore established.

Winter wheat.—Two varieties of winter wheat were tested, the Turkish Red and King's Early. These were sown September 5th and made an excellent growth before winter.

The Turkish Red yielded at the rate of 32.3 bushels per acre; the Kings Early, winter killed. Further trials will be made with the Turkish Red wheat.

Winter rye.—Two varieties of winter rye were tested, the Petkus and Schlansted, both of which gave good returns, as will be noted in the table.

Emmer.—Russian emmer was again tried, but the results will not permit us at this time to say much in its favor; further trials will be made, in which it will be tested for forage as well as growing it for a grain-producing crop.

The United States Department of Agriculture in Farmers' Bulletin No. 139, has the following to say regarding the name of this grain crop: "This grain is incorrectly called by various names. Even in certain reports of results of experiments with emmer it is sometimes called "spelt." The names "spelz," "speltz" and "spiltz" are also often used, the name speltz being the most common of all. These names are very misleading and should be discarded. Emmer is far the most satisfactory name and is easily learned. It is urged upon seedmen and others to join in discarding the name spelt, leaving it to be applied where it properly belongs."

Peas.—The Oddfellow, Early Britain and Prussian Blue peas were tested for the second year on the experimental plots, but the pea weevil had so badly affected the seed that only a part of those sown germinated. The stand was thin and the yields were very light compared with that of last year; no less than 50 per cent. of the crop were affected with weevil. The ravages of the pea weevil are so great that it seems useless to attempt to grow peas for seed in this portion of the state.

Germination of seed peas affected with weevil.—To determine the extent that the pea weevil affects the germination of seed peas several varieties were tested. Fifty affected peas were put in a seed tester May 6. Duplicate testers were also used with the same number of peas to verify the correctness of the original test. An equal number of peas not affected with weevil were placed in a tester at the same time, duplicate tests being also made.

May 11 an examination of the affected seed showed that only ten germinated. The peas that were not affected with weevil all germinated except three.

From these determinations it was found that the germinating power of the peas affected with weevil was 20 per cent. and that of the peas unaffected, 94 per cent.

Tests with different varieties of peas gave practically the same results.

Vetch.—Russian vetch was again grown for seed, but like last year the yield was very light, viz., 2½ bushels to the acre. Further trials will be made to grow it as a forage and a seed-producing crop.

II. VARIETY TESTS WITH FORAGE PLANTS.

Dwarf Essex vs. Puget Sound rape.—In this experiment two plots were sown, each containing one-twentieth of an acre. The seed was sown April 26 in drills, 30 inches apart, at the rate of 3 pounds to the acre. The seed germinated equally well and the characteristics of the plants were about the same throughout the growing period. The yield of green forage was slightly in favor of the Puget Sound rape, that variety giving a cutting on July 10 at the rate of 5.6 tons per acre, and the Dwarf Essex 5.2 tons. The hot, dry weather reduced the yield. Last year at the first cutting practically 20 tons of green forage per acre of Dwarf Essex rape was obtained of a much higher grade for feed. Rape requires cool weather and plenty of moisture to produce an abundant crop of high-grade forage. The hot, dry weather seems to thicken the leaves, making them less crisp and juicy and giving them a bitter taste which is not relished by the stock.

The Puget Sound rape seed used is of the Dwarf Essex variety and was grown near Puget Sound, in Washington. At the present time nearly all the rape seed used is imported from England and other European countries, but the yields of seed grown on the Pacific slope near Puget Sound is of such high grade that there is a possibility of our growing our own rape seed.

A fine sample of rape seed was sent the writer recently by Henry Barns, Union Grove, Racine county, Wisconsin. Mr. Barns states that he raised some on his farm, and that the plants thrive well in his county.

Rape sown with oats at the time of seeding for fall forage.— Dwarf Essex rape was sown with oats, at the rate of four (4) pounds of rape and three (3) bushels of oats per acre. The oats and rape were sown broadcast and were dragged in the regular way. Rape made its appearance above the ground a few days later than the oats, but was shaded by the growth of oats to such an extent that it did not interfere with the ripening of the oats.

The oats yielded at the rate of 32½ bushels per acre, nearly the average yield for this season. After harvesting the oats the rape came on rapidly and soon spread its green leaves over the stubble, making excellent pasturage for sheep, pigs, or cattle.

Another experiment was tried sowing rape with barley after the barley was about four inches above ground. This at first promised well; the rape seemed to catch nicely and made considerable growth, but the hot, dry weather wilted the slender plants so that few of them survived until the barley was harvested.

From experiments with rape carried on during the past two seasons the writer is fully convinced of its importance as a soiling crop and its excellence as a pasture plant for sheep, pigs and cattle.

On upland that is not too rich, rape can be sown with oats at the time of seeding and it will not, as a rule, interfere with the proper development or ripening of the grain. On low, rich soil the growth of rape is so rank in wet seasons that it materially interferes with the harvesting and curing of the oat crop and lessens the yield from 25 to 40 per cent.

It may be considerd a good plan to sow the rape at the time of seeding with oats on the drier and lighter soil, and on the low, rich soil after the oat plants are several inches above ground. It is well, if possible, when sowing the rape after oats are several inches high to select a time before or immediately after a rain in order to have the seed catch properly.

Rape seed is cheap, usually not more than eight (8) cents per pound in any seed store, and by an outlay of a small amount of money, any farmer can, therefore, have an abundant supply of summer and fall pasturage.

Caution should be used in putting sheep and cattle on the rape while they are very hungry, while the dew is yet on, or the rape frozen, for, like clover, it is liable to produce bloat or scours. After heavy frosts and cold weather sets in there is no gain by keeping stock upon the rape.

A former student of the College of Agriculture who has fed sheep and pigs extensively on rape for several reasons, accidentally let his sheep pasture on frozen rape and noted that nearly all scoured severely. Several of the lambs that ate of the frozen rape died and some never fully recovered from the effects of the severe scours obtained.

A portion of the flock pastured on frozen clover and were affected in the same way.

Trials with alfalfa.—April 28, 1900, six plots containing one-twentieth of an acre each were sown to alfalfa, at the rate of 20 pounds of seed per acre, with oats as a nurse crop. On one plot the oats were cut for hay June 30, and on a duplicate plot the oats were left to ripen and were harvested July 28th. On these two plots the oats had been seeded at the rate of three bushels per acre. The alfalfa on the plot where the oats were cut for hay made a rapid growth, was cut August 1, and yielded at the rate of 1.2 tons hay per acre. October 25 it was again cut and gave a yield of 1 ton hay per acre. The hay was of a fine quality and was eaten readily by horses, cattle and sheep.

The alfalfa on the plot where the oats were left to ripen made a good growth after the oats were harvested, and October 25 had a stand equal to that on the plot where the oats were cut for hay. The plot was pastured with sheep and eaten close to the ground to note the effect.

Four plots were sown to alfalfa with oats as a nurse crop. The oats on these plots were sown at the rate of 1 bushel per acre and left to ripen. The alfalfa looked vigorous and healthy and a good stand was left for winter protection.

The plot on which the alfalfa was cut October 25 and that which was pastured, close on the same date, winter-killed, and the plots on which the cover crop was left survived the winter and gave the following cuttings: June 15, 2.1 tons of hay per acre, July 15, 1.3 tons, and September 3, .22 of a ton.

This season Turkestan alfalfa was secured, a variety that is said to have special drought- and frost-resisting qualities. This was sown at the rate of 20 pounds of seed per acre on different plots with oats as a nurse crop, the latter being sown at the rate of 3 bushels per acre.

One plot was sown to alfalfa without a nurse crop. The oats were left to ripen on those plots where the alfalfa seeding was with the nurse crop, and when harvested the alfalfa seemed somewhat withered, but stood thickly. The plot on which the alfalfa was sown without a nurse crop as cut July 5, and yielded one-half ton hay per acre. The dry weather materially affected the growth of the Alfalfa, causing it to bloom a few inches above the ground, consequently a light crop was secured.

The drought-resisting qualities of the Turkestan alfalfa are superior to the American and European varieties of red clover. Ten varieties of red clover were tested on plots adjoining those on which the alfalfa was sown and all were killed by the severe drought, while the alfalfa is growing nicely and the ground is thickly covered with young plants.

The alfalfa on the plots on which oats were grown as a nurse crop seems to thrive fully as well as that on the plot where no nurse crop was grown. No difficulty was experienced keeping down the weeds on the plots where the nurse crop was sown, while on the plot where no nurse crop was sown the weeds were cut and pulled several times to prevent the shading of the alfalfa.

Alfalfa, like our clover, belongs to the family of legumes and has the facility of appropriating nitrogen from the air, by means

of numerous tubercles which grow upon its roots, and fixing the same within the soil. This remarkable plant was grown in Asia in ancient times and during one of the great Persian wars was carried westward into Europe and planted in the Swiss canton, Lucern. In Europe and in many states of America the plant is called Lucern, but in the north, eastern, and western parts of the United States it is known most largely by the name of alfalfa.

The value of alfalfa as a forage plant in the west is becoming more and more apparent and the area grown, which was very small a few years ago, has gradually widened, until at the present time most of the stock-producing states west of the Mississippi grow it in abundance. In Wisconsin alfalfa is yet in the experimental stage, with good prospects that it will prove a valuable forage plant; but until it had been further tried at the Experiment Station and by others selected by the Station to grow it in a careful way, it will be well for the farmers of the state not to sow it in too large quantities.

Variety test of clover.—To test the quality, hardiness and productiveness of the American red clovers compared with European clovers, the following varieties were sown in the spring of 1900 with oats as a nurse crop: American varieties, Medium and Mammoth red clovers; European varieties, Hungarian, English, Steinmark, Transylvania, Russian and German red clovers.

In testing these varieties one-twentieth of an acre plots were used and duplicate plots of each variety were tested as a check upon the original plots. The season of 1900 was favorable for the growth of clover and an excellent catch was obtained on all plots. The oats were sown on these plots at the rate of 3 bushels per acre and were left to ripen. The clover was sown at the rate of 8 quarts per acre. After the oats were harvested the clovers grew rapidly and before freezing weather checked the growth, a fine stand was obtained on all plots, which was left for winter protection.

In the spring (April 24) it was found that all European varieties had winter-killed, excepting the Russian and Hungarian varieties. The American varieties survived the winter and

looked much more vigorous than the European varieties that were not winter-killed.

The yield of hay per acre for the several varieties is herewith given with the date of cutting:

Name of Variety.	Date of Cutting.	Yield of Hay Per Acre.
Mammoth Red	July 1	3¼ tons.
Medium Red	June 20	2.6 tons.
Hungarian Red	June 20	2.2 tons.
Russian Red	June 20	2. tons.

The quality of hay secured was slightly in favor of the European varieties, it being finer in leaf and stalk and comparatively free from dust.

One of the special characteristics noticeable of the European clovers was the absence of the fuzz or feather from the leaves and stems, the presence of which is so noticeable on the American varieties and is one of the reasons for the amount of dust found in our clover hay.

Last spring a co-operative experiment was undertaken in connection with the United States Department of Agriculture with native and European varieties of red clovers, to determine their hardiness, quality and productiveness. The following varieties were used: English, Tennessee, Hungarian, Michigan, Minnesota, Steinmark, Canada, Italian, Missouri and Silician. These were sown April 27, without a nurse crop, at the rate of 15 pounds of seed per acre. The seed on all plots germinated well and from observations made June 1, a fairly good stand of clover was noticeable. The severe drought during the summer so affected the young plants that all of the European and Southern varieties were killed, and August 19 only a partial stand of the Canada, Michigan and Minnesota clovers was noticeable. It did not seem worth while to continue the experiment further, and the plots were plowed and sown to winter grain.

Clover seeding experiment.—The experiment started last year sowing clover with and without a nurse crop was finished this year. In the 17th annual report mention is made of sow-

ing plots to clover with and without a nurse crop. In each case the best stand of clover late last fall was in favor of the clover that had been seeded without a nurse crop and second, where the nurse crop was cut for hay.

One plot on which Mammoth red clover was seeded without a nurse crop, gave a cutting last season of 1.3 tons per acre and cut this season 4.1 tons per acre, making 5.4 tons of hay per acre.

A duplicate plot on which oats were sown as a nurse crop did not mature sufficiently to cut last fall, but gave a cutting of 3.2 tons per acre this season.

With the medium red clover two plots were sown last season with oats as a nurse crop; on one plot the oats were left to ripen and on the other the oats were cut for hay when they were fairly well headed. The plot on which the nurse crop was cut for hay gave a cutting, June 30, of 2.6 tons of oat hay per acre, and August 1, nine-tenths of a ton clover hay per acre was obtained. A good stand of clover was secured on both plots, slightly in favor of the plot on which the oats were cut for hay. This season the plot on which the oats were cut for hay gave a cutting of 2.8 tons hay per acre and the plot on which the oats ripened, a cutting of 2.6 tons per acre. The difference in the yield of hay per acre was not great, owing to the fact that the amount of moisture during the season of 1900 was sufficient to enable the clover to receive an ample supply, and on each plot a good stand was secured.

SUMMARY.

Where clover is seeded without a nurse crop or where the nurse crop is cut for hay a fairly good cutting of clover can be secured the first season. Where there is no lack of moisture the nurse crop can be left to ripen without much detriment to clover.

If the land is very clean a good catch of clover can be obtained by seeding without a nurse crop and a fairly good cutting of clover obtained the first season. If land is weedy and the season dry, more difficulty will be experienced in keeping the weeds down than by sowing with a nurse crop and cutting the

same for hay. The nurse crop will keep down the weeds and when cut, the clover soons gains the ascendency.

European varieties of clover make a fine quality of hay but lack the cold- and drought-resisting properties of the American varieties, thereby making a catch and stand of clover very uncertain.

Until the European varieties of clover become acclimated to this state, it is not advisable for farmers to invest in much seed, but they will do better to depend on our medium red clover, which seems to be the most satisfactory clover under our conditions of soil and climate.

Hungarian Brome Grass.—One-tenth of an acre was sown to Hungarian brome grass (*Bromus inermis*) the spring of 1899, at the rate of twenty pounds of seed per acre. A good catch was obtained and a dense growth of grass was secured, which did not appear to be in any way affected by the frost the following winter. The growth in the spring was rapid and in earliness it seemed to be at least two weeks in advance of other grasses. The grass stooled heavily and made a very heavy sod; it did not produce a very high growth, however, and gave a light cutting of hay, which was of a coarse quality. The same was true of the cutting this season; the density of the sod seemed to be such that vigorous growth was hindered.

April 25, 1900, three plots, 1/8 of an acre in size, were sown to Hungarian brome grass, at the rate of 16, 24 and 32 pounds of seed per acre. Oats were sown as a nurse crop and left to ripen. The ground used was sandy and being on a side hill was inclined to wash badly. After harvesting the oats, the brome grass came on rapidly, and October 16 had formed a fairly good sod and the grass looked vigorous. On the plot seeded at the rate of 32 pounds to the acre, the stand was the most satisfactory, and this was also plainly the case the following spring.

April 23, 1901. The grass stood four inches high and a good firm sod was formed which prevented further washing of the soil. The hot, dry weather following seemed to affect the growth materially and caused the grass to head near the ground. A very light cutting of hay was procured. After cutting, the grass did not start immediately, but appeared to dry down like

other pasture grasses and remained practically dormant during the dry weather. After the fall rains the grass started readily and at the present writing, September 2, is four inches high and stands evenly; no difference is noticeable between the thick and thin seeding.

From the tests made on the experimental plots, the brome grass seems especially adapted for early spring and late fall pasture; will form a strong sod on sandy soil that is inclined to wash and is drought-resisting to a marked degree.

The yield of hay has been light, of a coarse quality and is not eaten as readily by stock as timothy or clover.

The seed is as yet expensive, $2.00 per bushel of 14 pounds. Until more tests are made with this grass, it does not seem advisable for farmers to grow it on large areas. Experiments with it will be continued at this Station.

Soy Beans.—Soy beans were introduced into the United States from Japan and are now quite extensively grown in the south as a forage plant. Several of the western Experiment Stations have tested them and found them an excellent soiling crop. If cut at the proper time a fine grade of hay can be procured which is noted for its richness in protein.

The experiments carried on at the Wisconsin Station last year seemed to indicate, that while a large amount of green forage or hay could be produced, the plant matured so late that severe frosts prevented the ripening of the beans for seed.

The seed used this season was northern-grown, having been procured from Michigan; the test made largely to determine if soy beans would ripen in Wisconsin. The beans were sown in drills 32 inches between rows and about four inches between plants in the row, using about one and one-half pecks per acre. Several plots one-twentieth of an acre in size were planted May 14, and ten days later the plants were above ground. During the growing season the beans were cultivated twice, using a common one-horse cultivator. August 7, the beans were in full bloom and of even height of 3 feet (see Fig. 10). They were harvested October 2 and threshed, giving a yield of 22 bushels ripe seed beans per acre.

Soy beans are used largely as a human food in Japan, but

are used in this country chiefly for feeding stock. The plant belongs to the leguminous family and, like the clover, is a great nitrogen gatherer, gradually increasing the supply of nitrogen in the soil on which it is grown. This is true especially when the soil contains the bacteria which form tubercles on the roots of soy beans.

A portion of one plot was cut and gave a yield of 4 tons of green forage or 2¼ tons of cured hay per acre.

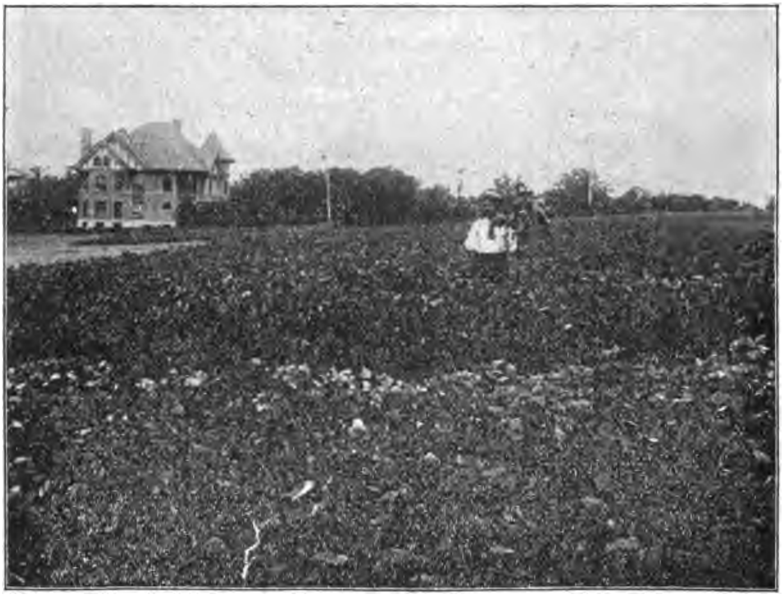


FIG. 56.—Plots of Soy Beans. A plot of Cow Peas in the foreground.

Stock of all kinds eat soy beans with a relish. It has great drought-resisting powers and flourishes in the hot, dry weather. From the information sent by former students of the College who are co-operating in carrying on experiments with soy beans, it is believed that many sandy farms, low in fertility, may produce a good crop of soy beans for pasturing or for soiling. Care should be taken to harvest soy beans before the severe fall frosts, as the pods crack open readily after freezing, thereby causing considerable loss.

Experiments with this plant will be continued next season.

Cowpeas.—The cowpea like the soy bean is a southern plant and has great drought-resisting powers. It is said to grow fairly well on sandy, worn-out soil and make excellent pasture for hogs, sheep and other farm animals, gradually enriching the soil on which it is grown. The cowpea should be sown broadcast when desired for pasture or to be cut for hay. When the object is to secure seed, they should be sown in drills, the rows about thirty inches apart, and the plants about six inches apart in the row. For broadcast seeding about 1½ bushels of seed per acre is used; 1½ pecks is sufficient when sown in drills. Cowpeas vary in color and resemble our different varieties of field beans very much. They grow erect or on creeping vines and have long pods containing from eight to sixteen peas in a pod. The peas when dry can be cooked or baked for human food and make a dish not unlike our navy beans in flavor and palatability. In the South they are grown as a forage plant for human food, but chiefly as a soil renovator.

The seed used in the experiment carried out at the Station were southern-grown of the Whippoorwill variety and were planted in drills, with rows 32 inches apart and the plants about six inches apart in the rows. The land was prepared in the ordinary way for field crops and the peas sown May 14th, with a hand drill, at the rate of 1½ pecks per acre. The cool weather following caused a delay in the germination of the seed and for several days after the appearance of the plants above ground they looked sickly, and it was not until after two weeks of hot weather that the plants began to grow vigorously. Some plants matured seed much earlier than others; these were designated and the peas picked several weeks in advance. The peas from these early plants will be used to propagate earlier maturing seed peas next season.

All plants did not mature the seed sufficiently before the heavy fall frosts, and only a portion of the crop was therefore secured.

The peas were harvested October 2nd, and yielded 9½ bushels per acre, weighing 57 pounds per measured bushel.

Further trials will be carried on at the Station on a more extensive scale the coming season.

TREATMENT OF SEED OATS TO PREVENT SMUT

R. A. MOORE.

Oat smut has been increasing at such a rapid rate in Wisconsin that it seems already to exist in all oat-growing centers of the state. To determine how widely the oat smut was prevalent and to what degree the oats were affected, the writer made investigations in the following counties during July and August this year: Dane, Grant, Crawford, La Crosse, St. Croix, Dunn, Wood, Marathon, Langlade, Marinette, Brown, Kewaunee, Manitowoc, Outagamie, Winnebago, and Fond du Lac. In making the tests a barrel hoop was used and on approaching the field was thrown over the standing grain. All stalks encircled by the hoop were then counted, and the percentage of smutted heads was determined. Several counts were made in each field and the determinations averaged.

Investigations were made in a number of fields in each county and by several careful counts in each field it was found that an average of 20 per cent. of the oats were destroyed by smut. A circular letter was sent to former Short-Course students and farmers in general to take note of the smut in their oat fields and make the determinations in accordance with the above directions and report the result. Seventy-five reports have been received from farmers and students residing in various parts of the state to show that the oat smut is everywhere prevalent in large quantities. The farmers are either not aware of the presence of smut in their oat fields, or they think it is present in small quantities only and not worthy of serious attention. In many instances where determinations were being made by the writer, the farmer was invited to assist in making the counts and great was the astonishment when from 20 to 40 per cent.

of smut was found in fields which he thought were absolutely free.

The smutted heads grow on weakly stalks and, as a rule, head lower than the fully-developed heads, making it hard to discover the affected heads by casual observation. It is largely from this fact that the smut has been able to invade the oat fields throughout the state unnoticed until the annual loss to the farmers of Wisconsin amounts to several hundred thousand dollars. This can all be saved by the formaldehyde treatment, a simple, inexpensive and entirely effective remedy. The method of application is as follows: One pound of 40 per cent. formaldehyde is required for each 50 bushels of seed to be treated; 50 gallons of water are poured into a cask and one pound of the formaldehyde liquid added; a part of this solution is placed in another cask. Two bushels of oats are placed in a large gunny sack and submerged for twenty minutes. By having two casks, two lots can be submerged at the same time, enabling one to treat the seed more rapidly. At the expiration of twenty minutes the sack is pulled on the edge of the barrel and left to drain for a minute or two in order to save solution; the oats are then emptied on the threshing floor or on a canvas to dry.

The treatment of seed should be made a few days in advance of sowing to enable the seed to dry sufficiently to run readily through the seeder or the drill. If the oats are shoveled over two or three times a day it materially facilitates the drying. If a farmer wishes to treat two or three hundred bushels of seed grain he can use several barrels or casks and make sufficient solution at one time to put in the barrels. In this way a sack of oats can be in each cask, thereby enabling the operator to treat several bushels every twenty minutes.

The solution is not poisonous in moderate amounts; oats that have been treated and dried can be fed to stock. If more oats are treated than needed for seed, it is advisable to mix the treated oats with oats that have not been treated before feeding. The grain sack or clothing coming in contact with the formaldehyde solution will not be injured. The solution will keep at any rate for a week or more, but it is advisable to cover up the cask when not used.

The treatment of seed oats seems to facilitate the sprouting. A difference of from two to four days in favor of the oats treated was noticeable this season.

From all field tests made no detrimental effect on the germination of seed was apparent.

Thirty varieties of seed oats threshed from plots on the University Farm on which the oats last year were affected from two to twenty per cent., were treated with the oat smut preventative before sowing and not a single affected head could be found during the growing period.

Formaldehyde is a gas readily soluble in water and is sold in liquid form, usually, in 40 per cent. solution, by most drug stores at about 50 cents per pound. A solution of the strength indicated is manufactured by different commercial houses under the name of formalin.

A like solution used for treating seed oats to prevent smut can be used for barley with the same effectiveness.

Trials with the formaldehyde treatment for oat smut.—In order to determine the most effective strength for a solution to be used and the length of time the oats should be submerged, several experiments were carried out.

Oats taken from a plot on which the crop was affected to the extent of 20 per cent. last season were used for the experiment. Six plots, 1-40 of an acre in size, were used for the trial and all seeded the same day. On plot 1 the seed oats were submerged for twenty minutes in a solution made at the rate of 1 lb. of formaldehyde to 50 gallons of water.

No smut was found in the oats growing on this plot, the treatment being entirely effective.

The treatment of the seed on the other plots will be compared with the treatment of the seed on plot 1.

In making the determinations to ascertain the percentage of oats affected with smut two methods were used: first, the method previously described by using a barrel hoop, and secondly, by cutting sufficient oats from the plot to make a bundle and counting all smutted stalks therein.

On plot 6, the seed oats were not treated and by several care-

ful counts an average of 31 per cent. of smut was found; nearly one-third of the oats were destroyed.

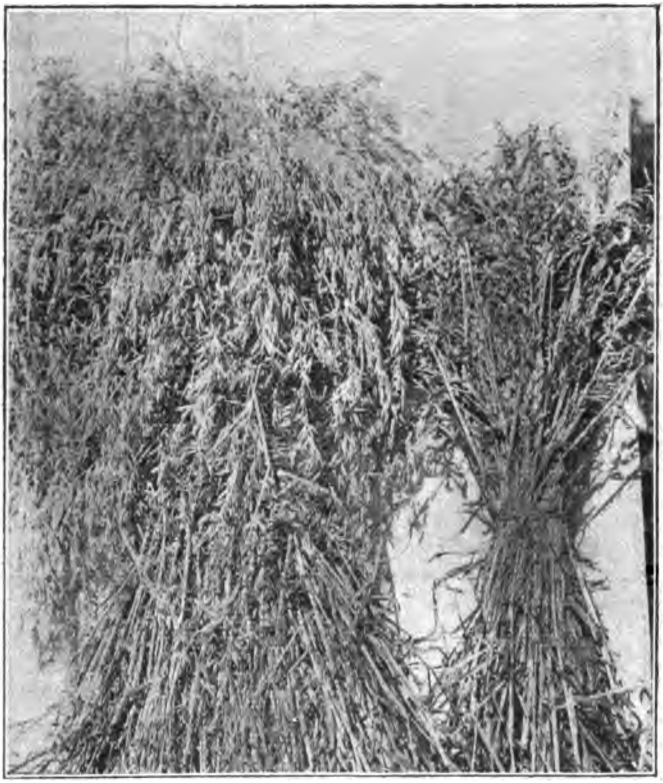
A bundle was cut on this plot which had 925 stalks by actual count. In this bundle was found 286 stalks on which the heads were affected by smut, giving a total loss of, approximately, 31 per cent. The several counts with the hoop averaged the same.

FIG. 57.—Containing 925 stalks. Bundle of oats cut from plot on which seed was not treated for smut. The smutted heads separated from those unaffected with smut shown in Fig. 58.

On plot 2, the seed oats were submerged 60 minutes in a solution made from one pound of formaldehyde and 200 gallons of water, three times the amount of time given for submerging and four times the amount of water used with a given amount of formaldehyde compared with the treatment prescribed for the oats on plot 1.

The treatment was only partially effective. The average of several counts showed 20 per cent. of the oats affected with smut.

Plot 3 compared with plot 1.—A solution of the same standard was used but the oats submerged one-half the time. The treatment was quite effective, only one per cent. of smut was found.



a b

FIG. 58.—a—Not affected with smut; b—Affected with smut. The smutted heads in the bundle represented in Fig. 57 separated from those not affected. The count revealed 286 heads affected with smut or 31 per cent. of the bundle affected.

Plot 4 compared with plot 1.—The oats were submerged for twice the length of time in a solution one-half the strength; 4.3 per cent. of smut was found.

Plot 5 compared with plot 1.—We submerged the oats the same length of time in a solution one-half the strength. Five

per cent. of the oats grown on plot five (5) were affected with smut.

It seems conclusive that the length of time the oats are submerged and the strength of the solution are very important factors to be considered when treating seed grain to prevent smut. In order to be entirely effective oats must be submrged in a solution made at the rate of one pound of formaldehyde to 50 gallons of water, for twenty minutes. This gives the solution sufficient time to soften the outside covering of the oats, enabling it to penetrate and kill the smut germs hidden away within the hull that would not be disturbed by a bath of only a few seconds.

A weak solution or a short period of submersion has only a partial effect; the results from the experiments tried showed the maximum of smut was reduced, yet it was not entirely eradicated. Where the treatment is not entirely effective, the few smutted heads will inoculate the perfect heads to such an extent that in two or three years the oats are affected as much as ever. Care should be taken to follow the instructions carefully, so the treatment will be entirely effective, for when once done effectually and a little care taken to prevent contamination of the oats by the thresher, several years may elapse before another treatment is necessary.

Summary of the foregoing experiments.

Seed Oats Submerged for	In a Solution.	Smut Found.
Twenty minutes	1 lb. formaldehyde to 50 gal. water.	0.0 per ct.
Sixty minutes	1 lb formaldehyde to 200 gal. water.	20.0 per ct.
Ten minutes	1 lb. formaldehyde to 50 gal. water.	1.0 per ct.
Forty minutes	1 lb. formaldehyde to 100 gal. water.	4.3 per ct.
Twenty minutes	1 lb. formaldehyde to 100 gal. water.	5 0 per ct.
Not treated		31.0 per ct.

EXPERIMENTS IN SUGAR BEET CULTURE DURING 1900 AND 1901.

F. W. WOLL AND ROSCOE H. SHAW.

Experiments in the culture of sugar beets were continued during the years 1900 and 1901 according to a similar plan as in previous years. The adaptability of the climate and, in general, of the soils of our State to the culture of sugar beets has been proved by the work done during the last ten years at this Station, and by the analyses of beets grown by farmers in all parts of the State. It has been found that in moderately favorable seasons good crops of beets containing a high percentage of sugar can be secured in all portions of our State except the southwestern corner, when proper attention is given to the culture of the crop. The general situation as to the adaptability of different parts of our State to sugar beets has been discussed in earlier reports and bulletins issued by our Station, and the reader is referred to these publications for details as to the results arrived at on this point, especially to our 17th annual report (pp. 244–246), with accompanying State map showing the average quality of sugar beets analyzed for Wisconsin farmers, during 1890–1899, by counties.

The work done in this line during the years 1900 and 1901 will be described under two headings: first, investigations at our Experiment Station farm, and, second, analyses of beets grown by Wisconsin farmers. All work, analytical and experimental, done on these investigations between Oct. 1st, 1900, and Oct. 1st, 1901, was done by Mr. Shaw.

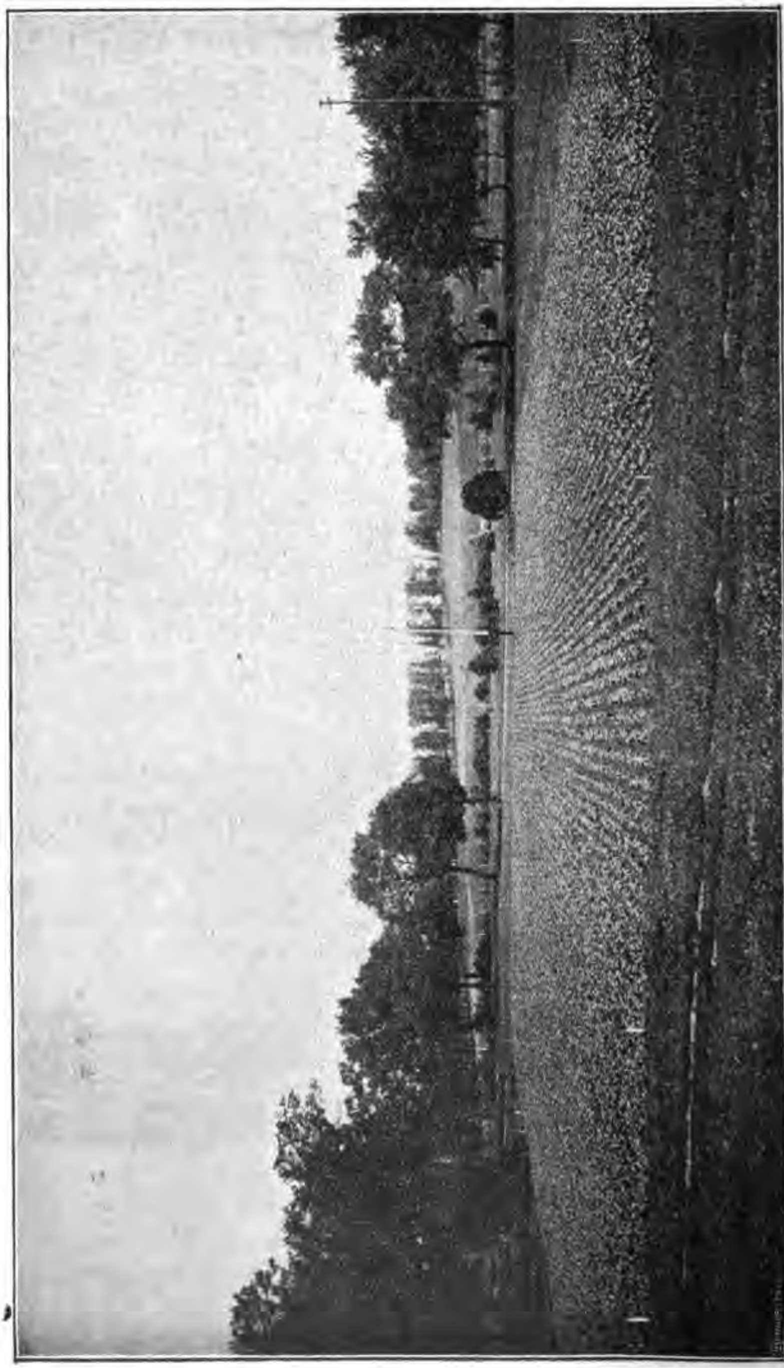


FIG. 59.—Sugar Beet field at the University farm, 1900.

A. EXPERIMENTS IN THE CULTURE OF SUGAR BEETS AT THE UNIVERSITY FARM.

Season 1900.—The season of 1900 was, on the whole, favorable to all farm crops except hay. The average temperature from April to September was 62.8°, which is about two degrees above normal, and the total precipitation was 22.89 inches, which is about 3.5 inches above the normal. There was a lack of rainfall during the early part of the season which was very damaging to crops in the northwestern counties and also greatly felt at Madison, retarding the beets in their growth at the start. Rain came during the last week of June, and from this time on the beets did very well and the crop obtained must be considered very satisfactory.

The field set apart for sugar beets this season was the western half of the acre plat on the university farm which was used for sugar beets in 1898 and for variety tests of grains during 1899. Only the southern half of the field was manured in 1898,* and no manure or fertilizer was put on the field in 1899. In order to ascertain in how far the results obtained in 1898, which were more favorable for all varieties grown for the unfertilized part of the field than for the fertilized part (loc. sit.) were accidental, or were due to a marked difference in the fertility of the soil on the two halves of the plat, a middle half of the field was fertilized on May 15th with 90 lbs. Star Phosphate (dissolved bone), 90 lbs. of sulfate of potash, and 100 lbs. of nitrate of soda, half of the latter quantity being put on May 15th and the other half shortly after the beets were thinned on June 19th. A northern and southern quarter of the field were left unfertilized. After the seed bed had been carefully prepared by means of a disc harrow and a Tower pulverizer, beet seed was planted on May 15th. A heavy rain fell as the seed was all in and especially the northeast corner of the field was badly washed; as the soil baked greatly during the following days, forming a crust which in all probability many of the young beet plants would not be able to break through, it was decided to reharrow and replant the field, except the part on which variety No. II (see below) had been planted, as no more of this seed was left.

*See Bulletin 71, p. 25.

The replanting took place on May 21; the following number of rows were planted with seed of the varieties given, the rows running north and south, 192 feet in length, and 15 inches apart:

No.	Name of Variety.	U. S. Dept. Agri. No.	No. of rows.
I...	Vilmorin White Imp. (France)...	3,941	13
II...	Zehringen (Strandes, Germany)...	3,942	9
III...	Austrian Spec. Kleinwanzleben...	...	7
IV...	Austrian White Improved...	...	5
V...	Austrian Queen of the North...	...	6
VI...	Kleinwanzleben (Mrozinski No. 1, Russia)...	3,943	12
VII...	Kleinwanzleben (Mrozinski No. 2, Russia)...	4,416	11
VIII...	Kleinwanzleben (Dippe Bros., Germany)...	3,944	12
IX...	Same as No. I, Vilmorin, France...	3,941	30

The seed was furnished by the Section of Seed and Plant Introduction, U. S. Dept. of Agriculture, except varieties III–V, inclusive, which were a choice grade of seed furnished by the Bureau of Chemistry of the U. S. Dept. of Agriculture. The beets came up evenly; when the young plants had three or four leaves they were thinned so as to leave a strong plant every eight to nine inches in the row; date of thinning, June 11 to 13. During the progress of the season there was soon a difference noticeable in the beets on the fertilized and the unfertilized parts of the field, the beets grown on the former showing in general a healthier, deeper green color of foliage and a more vigorous growth than those grown on the unfertilized parts on either side. There was also a marked difference in the appearance of the beets on the unfertilized north and south quarters, the healthiest plants in all varieties being found on the north quarter. No appreciable difference was to be observed at any time during the growing period between the different varieties as to luxuriance of growth or color of foliage.

Analysis samples of the varieties No. III to V were taken once before harvest, viz.: Sept. 1st; all beets in six feet of row were dug, weighed before and after topping, and two beets of

average size selected for analysis. The results of these analyses and of the analyses made at harvest time, Oct. 13–14, are shown in the following table:

Analysis of sugar beets, University Farm, 1900.

NUMBER AND NAME OF VARIETY.	PLAT A. (Not fertilized.)			PLAT B. (Fertilized.)			PLAT C. (Not fertilized.)		
	Wt. of beets	Sugar in juice.	Purity.	Wt. of beets	Sugar in juice.	Purity.	Wt. of beets	Sugar in juice.	Purity.
Samples taken Sept. 1.	Lbs.	Per ct.	Pr ct.	Lbs.	Per ct.	Pr ct.	Lbs.	Per ct.	Pr ct.
III. Kleinw., Austria..	.7	12.82	82.5	.5	14 85	86.2	.5	15.84	86.2
IV. Vilmorin, Austria..	.9	11.46	82.1	.9	12.87	83.7	.7	15.23	80.4
V. White Queen, Austria	.7	13.41	83.6	.5	14.40	84.1	.5	13.84	85 4
Average...............	**.77**	**12.56**	**82.7**	**.63**	**14.04**	**84.7**	**.57**	**14.97**	**84.0**
Samples taken at harvest.									
I. Vilmorin, France..	.6	13.42	78.9	.6	14.01	81.5	.8	14.44	83.1
II. Zehringen, Strandes	.7	14.14	82.2	.7	14.23	81.3	.7	14.69	85.4
III. Kleinw., Austria...	.6	14.28	82.0	.7	16.66	88.5	.6	16.28	85.8
IV. Vilmorin, Austria .	.5	16.64	84.9	.7	15.88	85 4	.8	16.20	89.0
V. White Queen, Austria	.7	17.54	84.7	.7	18.14	83.6	.3	19.80	87.7
VI. Kleinw., Russia (No. 1)..........	.7	15.48	81.5	.6	15.23	78.3	.7	15.42	79.1
VII. Kleinw., Russia (No. 2)	.7	13.36	64.2	.8	13.07	77.8	.7	13 19	77.6
VIII. Kleinw., Dippe....	.8	12 15	75.5	.7	15.70	86.4	.6	16.03	87.1
IX. Vilmorin, France..	.8	13 30	77.4	.8	14.76	82.5	.7	14.76	84.6
Average.........	**.68**	**14.48**	**79.0**	**.70**	**15.30**	**82.8**	**.66**	**15.59**	**84.4**
Av., excl. of VI and VII.	**.67**	**14.50**	**80.8**	**.70**	**15.63**	**84.2**	**.64**	**15.96**	**86.1**

The differences in the results of the analyses of the beets grown on the A and C plats (*not fertilized*) go in the same direction in case of all varieties but two and are due to differences in the chemical or physical condition of the soil in the northern and southern parts of the field. The results obtained in 1898 were therefore duplicated during last year. By reference to our 16th Annual Report, p. 257, it will be noted that the southern half during that season, although receiving a heavy dressing of complete artificial fertilizers, yielded poorer beets and a lower acreage than the northern unfertilized half. Both in case of the September analyses of the beets grown on plats III to V this year, and in the analyses made at harvest time, there was a general improvement in the content of sugar in the beets and in the purity of the juice, going from north to south. Nos. I and IX were the same kind of seed, and the results given in the pre-

ceding table suggest that the character of the soil going from east to west must have been quite uniform. We notice that the fertilized half of the field (B) produced generally beets of higher sugar content and purity than the unfertilized plat lying to the north (A) and lower than that to the south (C), and that the results for this plat are nearer those obtained on the latter plat than on the former, showing that the application of the fertilizers had a tendency to improve the quality of the beets produced, as it did the yield obtained, which will be presently shown.

Comparing the results obtained for the same varieties grown on the fertilized plat B, with the average of those for beets grown on the unfertilized plats (A and C), we find that the quality of the beets as regards sugar content was improved through fertilization in four cases and somewhat decreased in five cases, the average being for the fertilized plats 15.30 per cent., and for the unfertilized plats 15.03 per cent. In the same way the purity of the beets grown on the fertilized plat was increased over that of beets grown on the unfertilized plats from 81.7 to 82.8 per cent.

The yields of total and of trimmed beets, as well as of sugar in the beets, in case of the different varieties are shown in the following table which gives the sum of the yields from the two unfertilized plats and those from the fertilized plat:

Yields of beets and sugar, University Farm, 1900.

No. of Variety.	No. of rows.	Plats Not Fertilized (A and C).			Fertilized Plat (B).		
		Total beets.	Trimmed beets.	Sugar.	Total beets.	Trimmed beets.	Sugar.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
I.........	13	1,198.4	930.5	123.1	1,363.6	1,080.7	143.6
II.........	9	828.0	615.0	84.2	846.4	650.0	87.9
III.........	7	542.9	439.4	63.8	841.6	681.9	107.6
IV.........	5	397.8	325.2	50.6	427.6	344.8	52.0
V.........	6	488.5	398.9	69.8	563.1	448.2	77.3
VI.........	12	1,101.8	819.7	120.3	1,236.3	1,071.6	155.5
VII.........	11	896.5	741.8	93.5	1,092.6	904.1	112.3
VIII.........	12	1,360.0	1,137.5	152.3	1,465.6	1,192.6	177.8
IX.........	30	2,287.2	1,814.7	354.4	2,711.5	2,197.1	308.2
Total....	....	9,101.1	7,222.7	1,012.0	10,548.3	8,571.0	1,222.2

The total yields of beets from the unfertilized plats were 9,101.1 lbs., and from the fertilized plats 10,548.3 lbs., or 31,460 and 36,470 lbs. per acre, respectively,—an increase of 2½ tons; in the same way there was an increase in the yield of sugar at the rate per acre from 3,497 to 4,226 lbs., or 729 lbs. The total sugar divided by the yield of beets gives as the average per cent. sugar in the beets grown on the unfertilized plats 14.01 per cent., and in those grown on the fertilized plat 14.26 per cent., an increase of a quarter of one per cent. Comparing the cost of the fertilizers applied with the value of the increase in the tonnage and quality of beets obtained we find that the application was not a paying investment, since the fertilizers cost at the rate of about $22.60 per acre, and the value of the increased yield of beets would at all events not exceed $12. As the application of fertilizers was a very heavy one, it could hardly be expected that the crop harvested should pay for the fertilizers used. The experiment was planned to throw light on the difference in the state of fertility of the different parts of an apparently homogeneous piece of land and not for the purpose of ascertaining at what point an economical application of artificial fertilizers would lie.

The total yields of beets from seed of different origin and of sugar per acre are shown in the following table; varieties I and IX from the same seed are here added together:

Total yields of different varieties from whole field.

PLAT NUMBER.	Area of Plat.	Total beets from plat.	Av. pr ct. sugar in beets.	CALCULATED YIELD PER ACRE.	
				Beets.	Sugar.
	Sq. ft.	Lbs.		Lbs.	Lbs.
I and IX	10,320.0	7,560.7	13.77	31,930	3,501
II	2,160.0	1,674.4	13.60	33,770	3,469
III	1,680.0	1,384.5	15.29	35,910	4,444
IV	1,200.0	825.4	15.31	29,960	3,724
V	1,440.0	1,051.6	17.36	31,810	4,449
VI	2,850.0	2,338.1	14.58	35,370	4,172
VII	2,610.0	1,989.1	12.51	32,830	3,396
VIII	2,830.0	2,825.6	14.17	42,740	4,992
Total	25,200.0	19,649.4	14.15	33,970	3,862

The average yield of beets per acre came to nearly 17 tons, and that of sugar to 3,862 lbs., the average sugar content of the trimmed beets being 14.15 per cent.

It will be seen that the varieties ranged in the following order:

As to yield of beets: Kleinwanzleben Dippe, Austrian Kleinwanzleben, Russian Kleinwanzleben (No. 1), Zehringen, Russian Kleinwanzleben (No. 2), Vilmorin France, Austrian Queen of the North, and Austrian White Improved.

As to yield of sugar: Kleinwanzleben Dippe, Austrian Queen of the North, Austrian Kleinwanzleben, Russian Kleinwanzleben (No. 1), Austrian White Improved, Vilmorin France, Zehringen, and Russian Kleinwanzleben (No. 2).

As to the per cent. of sugar in the beets: Austrian Queen of the North, Austrian White Improved, Austrian Kleinwanzleben, Russian Kleinwanzleben (No. 1), Kleinwanzleben Dippe, Vilmorin France, Zehringen, and Russian Kleinwanzleben (No. 2).

Season 1901.—The season of 1901 was as a whole very unfavorable to most crops in Wisconsin. The extremely hot and dry weather during July and August did great damage to crops all over the State, the southern part of the State suffering most from the drought. The average temperature of July was 4.8° above normal, and in the region along the western border of the State the average for this month rose 10° F. above the normal temperature. The rainfall during the season was very uneven, the average for the northern and central counties being nearly 23 inches for the seven months, March to Sept., and only about 14 inches for the southern counties. The total rainfall for the seven months was on the average for the whole State 20.41 inches, which is two-thirds of an inch below normal.

The plat set apart for the sugar beets at the University Farm was a piece of land about one-half acre in area (155 ft. by 141 ft.), in the northwestern portion of Randall field. The field has been used as a pasture ever since this region was settled, and was in corn last year. During late years prior to 1900 it served as a pasture for sheep or cows, but has never been otherwise manured. The soil is a clay loam and, like most of the land on

the University Farm, has a tendency to bake after rains. The land produced a very good corn crop last year, and as regards its state of fertility should have been well adapted to the production of sugar beets; the lower part of the field slopes toward the northeast, and the unevenness in the soil in different parts of the field thus introduced rendered it somewhat unsatisfactory for variety tests. The land was plowed early in the spring of 1901 and a few weeks later prepared in the usual manner for the planting of the beet seed by discing and pulverizing. The planting was done by means of a hand seed drill on May 17, in rows running north and south, 18 inches apart. The experience of last year was duplicated this spring since a hard crust was formed on the land through heavy rains a few days before the young plants began showing themselves above ground. As many of the young plants most likely would have been unable to break the crust formed, it was decided to reharrow and replant the entire plat and this was accordingly done on June 7th. The following varieties were planted:

No.	Name of variety.	U. S. Dept. Agri. No.	No. of rows.
I	Vilmorin, Very Rich	5,769	8
II	Dippe, Kleinwanzleben	5,772	8
III	Hoerning, Kleinwanzleben	5,771	7
IV	Elite sugar beet seed	....	7
V	Wohanka's Zuckerreicher	....	7
VI	Wohanka's Extrareicher	....	8
VII	Meyer's Friedrichwerther Elite	6,359	23
VIII	Dippe, Kleinwanzleben	5,772	23

The origin of the seed planted was as follows: Varieties Nos. I, II and III, U. S. Dept. of Agriculture, Section of Seed and Plant Introduction; Nos. VII and VIII, U. S. Dept. of Agriculture, Bureau of Chemistry; No. IV from the Sugar Beet Gazette, Chicago, Ill.; Nos. V and VI, Bohemian sugar beet seed from Wohanka & Co., Prague.

The plants began appearing above ground about June 14; a terrific thunderstorm occurring on June 16 did great dam-

age to the beets, as to all crops in this vicinity, and the soil of the eastern part of the field was badly washed, in places to a depth of two to three inches; in other places the young beet plants were covered to a similar depth. The field was thoroughly hoed, as soon as the land could be worked, and although the crop at first seemed entirely ruined, the beet plants gradually recovered; in the eastern part, however, they seemed struggling for existence against heavy odds for a week or more. The plants were thinned on June 27th—July 1, a strong plant being left every 9 inches in the row. Owing to the severe drought no transplanting was attempted. For over a month after this date no rain fell and the beets grew but little, the best stand being in the southwest corner and the poorest in the southeast corner of the field. The drought in this vicinity completely ruined some crops and the prospects were at this time that there would not be a yield of 50 per cent. of average of any crop. The sampling of the beets for analysis was done for the first time September 25, and from that time up to harvest, variety No. VIII was sampled every week. The results of the analysis are given in the following table:

Results of analyses of sugar beets, University Farm, 1901.

Date of sampling.	No. of variety.	Av. weight of trimmed beets.	Sugar in		Purity of juice.
			Juice.	Beets.	
		Lbs.	Per cent.	Per cent.	Per cent.
Sept. 25	I	.9	10.63	10.1	80.0
	II	.5	12.25	11.6	70.2
	III	.6	11.60	11.0	75.4
	IV	.5	12.13	11.5	68.4
	V	.6	12.19	11.6	73.6
	VI	.5	11.71	11.1	70.6
	VII	.6	12.69	12.1	75 4
	VIII	.6	12.60	12.0	77.2
Oct. 4	VIII	.5	13.69	13.0	78.4
Oct. 11	VIII	.67	10.75	10.2	71 6

The sampling of No. VIII was done by digging all beets in 60 feet of row of average luxuriance and selecting three beets

from the lot. Samples of this variety were forwarded to Washington to the Bureau of Chemistry, U. S. Dept. of Agriculture, at the request of the chemist, Dr. Wiley. The other varieties were sampled by digging the beets in 12 feet of the row and selecting three average beets of those dug. The low results of analyses were due to the immature condition of the beets. A rainy period set in on October 7th which lasted for 5 days; over two inches of rain fell during this time. The weather was raw and cold during the following days; the harvesting of the beets was postponed as long as practicable so as to give the beets a chance to mature; other farm work and the uncertainty of the advanced season rendered it necessary, however, to begin the harvest on October 18th. At that time the beets looked as if they were still growing; but few dead leaves were observed, and the general appearance of the beets was green and thrifty. The beets on the western half of the plat looked much better than those on the eastern half. There was no difference in the appearance of the beets that with any certainty could be referred to differences in the kind of seed used.

A bushel basket of beets was taken from each load hauled off the field (one to two bushels of each variety); the samples thus secured were washed to determine the amount of adhering dirt. The shrinkage amounted to 2.8 to 8.8 per cent. for the different varieties, and on the average to 5 per cent. The results obtained at harvest are shown in the following table:

Sugar beets at University Farm, season 1901.

VARIETY NUMBER.	Area of plat, sq. ft.	WEIGHT OF BEETS.		Sugar in beets, per cent.	Sugar per acre, lbs.
		From plat, lbs.	Per acre, tons.		
I	1,860	1,087	12.7	10.3	2,616
II	1,860	1,167	13.7	10.7	2,925
III	1,627	931	12.5	13.3	3,316
IV	1,627	836	11 2	11.1	2,485
V	1,627	815	10.9	12.1	2,641
VI	1,860	856	10.0	12.7	2,546
VII	5,445	2,572	10 3	10.6	2,181
VIII	5,445	2,482	9.9	10.9	2,165
Total and averages	21,351	10,746	**10.97**	**11.5**	**2,623**

If the results for varieties Nos. II and VIII are averaged, and also those for Nos. IV and VII, we arrive at the following comparative order of the different varieties of seeds as to yields of beets and of sugar per acre and average per cent. of sugar in the beets:

Relative rank as to yield of beets: Vilmorin's Very Rich, Hoerning's Kleinwanzleben, Dippe Kleinwanzleben, Zuckerreicher, Meyer's Friedrichwerther Elite, and Extrareicher.

As to yield of sugar: Hoerning Kleinwanzleben, Zuckerreicher, Vilmorin's Very Rich, Dippe Kleinwanzleben, Meyer's Elite, and Extrareicher.

As to per cent. of sugar in the beets: Hoerning's Kleinwanzleben, Zuckerreicher, Meyer's Elite, Dippe Kleinwanzleben, Extrareicher, and Vilmorin's Very Rich.

The low results obtained during the past season with the University Farm beets were somewhat of a surprise to us, although we did not expect much this year, from the adverse conditions under which the beets grew throughout the season, the most important of which was the late date of planting. The peculiar climatic conditions, with the short growing period which the beets had, fully explain the results and also show that soils which in ordinary seasons will produce rich beets, higher in sugar than the common factory standard by at least several per cent., as has been generally the case on our University Farm soil, may with the same kind of careful culture under exceptionally unfavorable conditions produce beets that would not be accepted at a sugar factory. The results of the analyses of beets grown by Wisconsin farmers during this season, which are given below, show that similar conditions did not prevail in all other portions of the State; for three to four weeks after the beets were harvested the weather was most favorable to the maturing of beets, being sunshiny and quite warm, and if the harvesting could have been postponed for this period there can be no doubt but what the results would have been nearly up to the standard set by earlier work in this line done at our Experiment Station. This would, however, have brought the harvest nearly a month and a half later than in earlier years, which under ordinary fall conditions would be impracticable or at least quite

inconvenient. The possible improvement of beets during the weeks following the harvesting is suggested both by comparisons of analyses of beets received from outside points before and after the time of our beet harvest and from what we know of the relations of weather conditions to the quality of the beets grown.

B. ANALYSES OF BEETS GROWN BY WISCONSIN FARMERS, 1900 AND 1901.

During both these years beet seed was distributed for trial purposes to Wisconsin farmers who applied for it or were known to be interested in the culture of sugar beets. The interest in sugar beets has been stimulated during the present year by the establishment of the beet sugar factory of the Wisconsin Sugar Company, at Menomonee Falls, Wis. Most of the samples received for analysis during this fall have been forwarded by farmers furnishing beets to this factory as its regular patrons, or for trial with a view of establishing sugar factories at neighboring points in the near future. Thirty-four samples of beets were received and analyzed during the fall of 1900, and 249 samples during this fall up to Dec. 1st. The results of the analyses made during both years have been summarized by counties and are given in the following table.

Summary of analyses of sugar beets, seasons 1900 and 1901.

Name of county.	Year.	No. of samples analyzed.	Weight of trimmed beets.	Sugar in juice.	Purity of juice.
			Lbs.	Per cent.	Per cent.
Adams	1901	1	.8	18.20	85.0
Brown	1900	8	2.2	14.15	79.0
Brown	1901	1	2.5	15.73	80.5
Calumet	1901	4	.9	19.78	82.4
Chippewa	1901	3	.8	16.61	82.3
Clark	1900	1	1.5	15.40	81.5
Columbia	1900	1	2.7	10.91	66.1
Columbia	1901	5	.9	15.86	80.2
Dane	1901	4	1.3	11.77	70.1
Dodge	1900	7	2.3	13.63	78.9
Dodge	1901	108	1.0	14.83	81.0
Florence	1901	2	.9	14.42	77.9
Fond du Lac	1901	2	.9	15.50	79.8
Grant	1901	1	.9	15.37	75.3
Jefferson	1901	51	.8	18.17	82.1
Kenosha	1901	1	1.4	16.49	76.0
La Crosse	1901	1	.8	16.06	85.5
Marathon	1901	7	.7	16.83	83.2
Marquette	1901	2	.6	16.68	78.5
Milwaukee	1900	1	2.5	13.59	76.8
Milwaukee	1901	10	1.2	16.67	80.6
Ozaukee	1901	16	1.1	17.90	80.7
Polk	1901	1	1.7	15.49	84.3
Racine	1901	1	1.5	13.78	76.1
Sauk	1901	1	1.9	16.90	77.7
Shawano	1900	2	1.5	16.26	80.0
Sheboygan	1901	1	2.2	12.90	76.4
Walworth	1900	2	1.3	10.70	70.2
Walworth	1901	5	.9	15.64	74.4
Washburn	1900	1	2.0	14.88	81.3
Washburn	1901	1	1.9	17.58	86.8
Washington	1900	3	1.8	16.16	76.4
Washington	1901	2	1.5	17.99	83.8
Waukesha	1900	8	1.1	16.04	81.6
Waukesha	1901	7	1.4	15.63	78.3
Waupaca	1901	10	1.4	17.35	77.6
Winnebago	1901	1	.5	15.71	86.6

The results obtained during the past two years go in the same direction as those found in previous years and give new proof of the adaptability of the eastern portion of our State to the culture of sugar beets. The number of samples received from other portions of the State where sugar beets of high sugar contents and purity have been grown in earlier years, is too small to signify much in discussing in how far these regions are adapted to sugar beet raising. But few farmers furnished information as to the yields of beets harvested by them; the mean of data furnished on this point during the season of 1901 would indicate that crops of twelve to fifteen tons were obtained, on the average. As most of our correspondents described the season as "very unfavorable" or "to dry," it is likely, however, that this estimate is considerablv too high, and ten to twelve tons would perhaps be a more representative average yield for the past season.

As an example of the high grade of sugar beets which can be grown in our State even by farmers who have had but little experience with this crop, the following analyses of sixteen samples of beets grown by members of the Watertown Beet Growers' Association are here given. The samples were received in one shipment on Nov. 20th, and were from beets harvested about Nov. 1st, or during the early part of the month. All samples were in good condition when received and analyzed, and had not to all appearances wilted during storage.

Results of analyses of beets grown by Watertown Beet Growers' Association.

Station No.	Weight of trimmed beets.	Per Cent Sugar		Purity of juice.
		In juice.	In beets.	
				Per cent.
250	.7	19.93	18.9	85.6
251	.7	21.12	20.1	90.0
252	.7	21.55	20.5	83.5
253	.6	21.47	20.4	86.9
254	.9	20.23	19.2	80.0
255	.7	20.75	19.7	83.4
256	.6	21.76	20.7	81.4
257	.4	22.26	21.2	84.0
258	.4	20.88	19.8	86.2
259	.7	20.97	19.9	86.9
260	.4	22.36	21.3	82.3
261	.7	20.57	19.5	87.0
262	.5	20.21	19.2	86.8
263	.5	20.04	19.0	86.5
264	.4	21.66	20.6	92.3
265	.7	18.48	17.6	82.2
Average for sixteen samples	.6	20.80	19.8	85.3

The analyses of beets grown in this locality, as well as in the entire lake region and the adjoining counties of our State, show that the cultural side offers no difficulties for the establishment of beet sugar factories. The results suggest that other factories that may be established will receive the hearty co-operation of farmers as soon as these are convinced that the factories have sufficient financial backing to give promise of success and are started in a business-like way.

It may not be out of place to mention in this connection that Wisconsin's first beet sugar factory, at Menomonee Falls, Wis., has been in successful operation for about a month at the present writing (Dec. 7). During this time, according to a communica-

tion received from the president of the Wisconsin Sugar Company, Mr. R. G. Wagner, twelve million pounds of beets have been sliced, producing about 3,500 barrels extra-fine granulated sugar. It is expected that the factory during the month of December will reach full capacity, working 500 tons of beets per day. The average sugar content of beets received up to this time is about 14.5 per cent.; this must be considered a most satisfactory showing, especially for the first year.

ANALYSES OF LICENSED FERTILIZERS IN WISCONSIN 1901.

F. W. WOLL AND ALFRED VIVIAN.

The following manufacturers have taken out a license for the sale of the brands of fertilizers given, in this State during the current year, in accordance with Wisconsin statutes of 1898, sec. 1494c:

Station No.	Name of Manufacturer.	Name of Brand.
41	Darling & Co., Chicago, Ill............	Darling's Tobacco Special.
42	Currie Bros., Milwaukee, Wis.....	Currie's Complete Fertilizer for Lawns, Hay and Pasture.
43	Milwaukee Tallow and Grease Co., Milwaukee, Wis..................................	Milwaukee Tallow and Grease Co.'s Bone Meal.
44	Armour Fertilizer Works, Chicago, Ill	Bone Meal.
45	Armour Fertilizer Works, Chicago, Ill	Ammoniated Bone and Potash.

The Station analyses of the brands given are shown in the following table. According to Wisconsin statutes of 1898, section 1494c, each manufacturer "shall affix to every package of fertilizer sold . . a statement of the following fertilizing constituents, namely: The percentage of nitrogen in an available form, of potash soluble in water, and of available phosphoric acid, soluble and reverted, as well as total phosphoric acid." The guaranteed composition of the licensed fertilizers is given in the table in connection with the results of our analyses of the samples furnished by the manufacturers in compliance with the State fertilizer law.

Analysis of licensed commercial fertilizers in Wisconsin, 1901.

Station No.	NAME OF BRAND.	Moisture.	NITROGEN.		PHOSPHORIC ACID.							POTASH.	
			Found.	Guaranteed.	*Soluble.*		Reverted.	*Available.*		*Total.*		Found	Guaranteed.
					Found.	Guaranteed.		Found.	Guaranteed.	Found.	Guaranteed.		
		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.
41	Darling's Tobacco Special........................	5.00	3.36	3.3	4.68	....	2.64	7.32	7.0	11.91	8.0	7.89	7 0
42	Currie's Complete Fertilizer for Lawns, Hay, and Pasture..................................	2 00	5.13	5.1	.50	....	2.78	3.28	....	12.70	12.7	7.88	7.8
43	Milwaukee Tallow and Grease Co.'s Bone Meal..	5.00	4.20	4.0	....	....	....	....	....	22.26	20.0	....	....
44	Bone Meal....................................	4.90	4.10	2.5	....	....	....	....	....	21.58	21.0	....	....
45	Ammeniated Bone and Potash..................	7.84	2.10	2.4	4.76	......	2.79	7.55	6.0	10.00	8.0	2.50	2.0

The mechanical analysis of the samples of bone meal included among the licensed brands of fertilizers gave the following results, the portion passing through a sieve of one-fiftieth inch mesh being designated as *fine-ground*, and that remaining on such a sieve as *coarse*.

Mechanical analysis of bone meal.

Station No.	Brand.	Fine-ground	Coarse.
		Per ct.	Per ct.
43	Milwaukee Tallow and Grease Co.'s Bone Meal	89	11
44	Bone Meal	59	41

Fertilizer inspection.—It is impossible to tell from the appearance or odor of a commercial fertilizer whether it contains a large amount of valuable fertilizing ingredients or only a very small amount. There is therefore a strong temptation for irresponsible parties to make and sell inferior or even valueless goods as standard fertilizing articles; so much so, that it has been found necessary in all states where the fertilizer business has grown to be of any importance, that the state should in some way supervise their sale. Laws regulating the sale of commercial fertilizers are at the present time in force in a large majority of the states of the Union. The Wisconsin fertilizer law which was passed by the legislature in 1895 is given in full at the end of this report. According to the provisions of the law, all commercial fertilizers sold in this state at a cost exceeding $10.00 per ton are to be licensed. They must be sold on a guarantee of certain amounts of valuable fertilizing ingredients contained therein, and the director of the experiment station, on whom is laid the duty of enforcing the law, is authorized, in person or by deputy, to take samples of all commercial fertilizers sold in this state which come within the scope of the law. In case of licensed fertilizers it may thus be ascertained whether these come up to the guaranteed composition, and when it is found that parties are selling fertilizers without complying with the provisions of the law, the offenders may be

brought before the proper legal authorities and convicted according to section 1494d of Wisconsin statutes of 1898. This section imposes a fine of $100.00 for the first offense and $200.00 for each subsequent offense.

It is hoped that all dealers in commercial fertilizers in the state will comply with the law in all particulars, and that they as well as purchasers of such fertilizers, will assist in the enforcement of the law by giving notice of violations of the same. A strict compliance with the law is for the best interests of all honest dealers and consumers alike. Only firms that live up to the requirements of the law and have taken out licenses for the sale of their brands of fertilizers should be patronized; the law does not offer purchasers any protection against dealers in other states who sell inferior or fraudulent goods.

AN APPARATUS FACILITATING THE ANALYSIS OF SUGAR BEETS.

ROSCOE H. SHAW.

With the idea of lessening the time required in the analysis of sugar beets, a simple apparatus has been devised by the writer to facilitate the determination of the specific gravity of the juice and the preparation of the same for the polariscope. Hoping that it may prove of some value to chemists engaged in sugar beet work, a diagram sketch and description of the apparatus is herewith published.

In the chemical laboratory of this Experiment Station the method employed in the determination of sugar in the juice of sugar beets is briefly as follows: the specific gravity of the expressed juice is found by means of a Westphal balance; 50 c. c. of the juice is then clarified with lead subacetate, made up to 100 c. c., filtered and polarized in a 200 mm. Pellet overflow observation tube with a Schmidt & Haensch half-shadow polariscope. The percentage of sugar is then calculated from the specific gravity and the polariscope readings by the tables compiled by Dr. Chas. A. Crampton.

The apparatus consists of a cylinder *a,* an overflow pipette *f,* a graduated burette *h,* a receptacle for distilled water *i,* connections, etc. The cylinder *a* is about seven and a half inches high with an internal diameter of about one inch. It is provided with an outlet petcock *c,* so arranged that it completely drains the cylinder, and a funnel *b* which is fastened to the inside of the cylinder by any convenient means, dissolved rubber being used in our apparatus. It sets with a Westphal balance on a secure stand fourteen inches above the operating table.

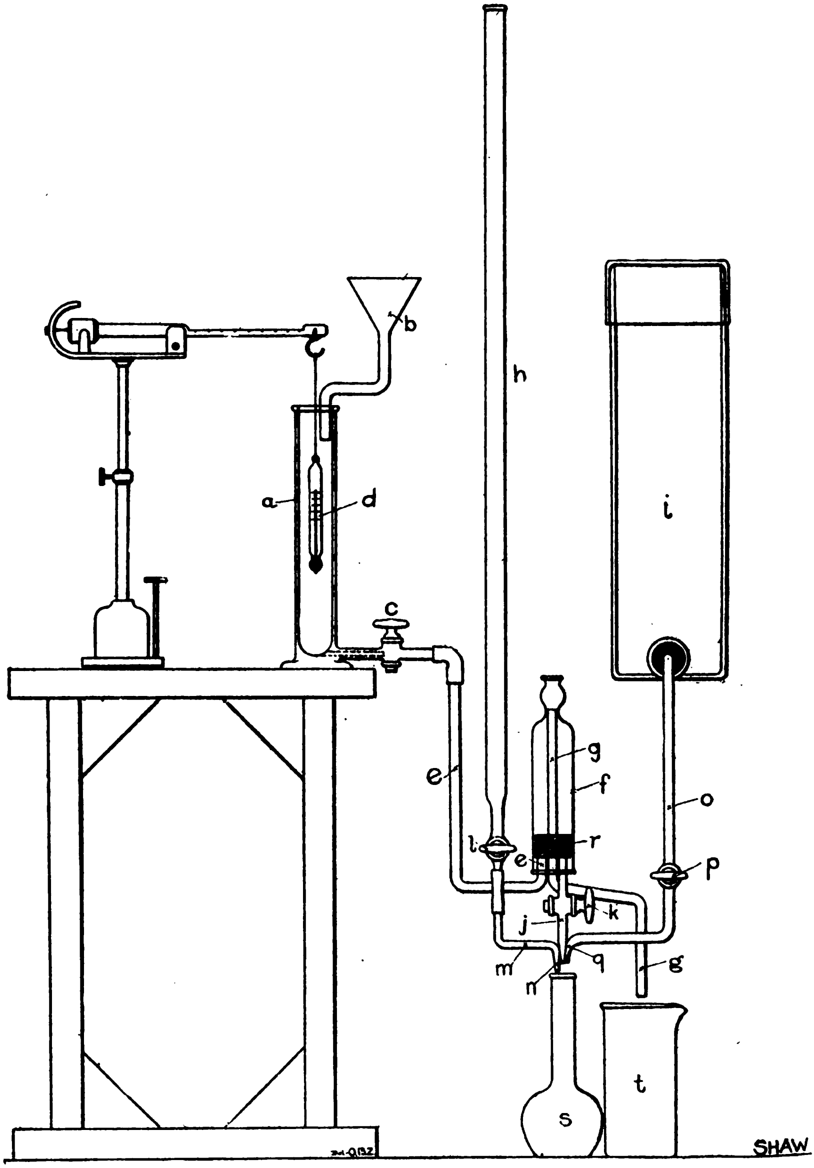


FIG. 60.—Apparatus used in the analysis of sugar beets.

The balance is so adjusted that the bulb *d* plays freely in the center of the cylinder. Cylinder *a* is connected with the overflow pipette *f* by means of the tube *e, e*.

The overflow pipette *f* is constructed from a piece of glass tubing of one inch internal diameter, by drawing it out to a narrow neck at a point about four and a half inches from one end of the tube and then blowing an open bulb, as is shown in the figure. The pipette with bulb is about five and a half inches long. It is provided with a rubber stopper which slides rather tightly inside, and through which run the inlet tube *e, e*, the outlet tube *j*, and the overflow tube *g*, which has its outlet at the back of the apparatus into any convenient receptacle *t*. The outlet tube *j* is provided with a petcock *k*. The pipette is calibrated by so adjusting the rubber stopper and overflow tube that when the latter has its inlet at the narrow neck of the tube exactly 50 c. c. of juice will be delivered through the outlet *j*.

Burette *h* has a capacity of 50 c. c. graduated to tenths (not shown), is provided with a petcock *l* and is connected by a piece of rubber tubing to an S shaped tube *m*, which is drawn out at the end and projects one-half inch lower than outlet tube *j*.

The receptacle for distilled water *i* of any convenient capacity has its outlet tube *o*, provided with a petcock *p*, and ends in a drawn-out point *q* which ends flush with the point of tube *j*. The three outlet tubes *j*, *n* and *q* are fastened together by means of a rubber tube so that they will readily enter the neck of an ordinary 100 c. c. graduated sugar flask.

In using the apparatus the cylinder *a* is filled nearly to the top by pouring the expressed juice through the funnel *b*. The petcock *c* is then opened until the level of the juice reaches a point in the cylinder previously determined by distilled water to give the reading 1.0000. This serves the double purpose of avoiding the error caused by the displacement by the wire supporting the bulb and rinsing the apparatus of its previous contents. Further rinsing is unnecessary. The rinsings are drawn off through *j*.

The specific gravity of the juice is then determined as usual by weighing the bulb in the juice. When this is accomplished

the petcock *c* is again opened and the juice allowed to flow out until the overflow tube *g* begins to work. Petcock *c* is now closed and a graduated 100 c. c. flask is placed under the three outlet tubes *j*, *n* and *q*. Petcock *k* is now opened and the juice allowed to flow into the flask. While the juice is flowing, 2 c. c. of lead-subacetate solution is run in from the burette through *m*, *n*, and a slow stream of distilled water from *i* through *q*. When the overflow pipette is emptied of its contents, additional water is allowed to flow in until the mark is reached. After being shaken and filtered the solution is ready for the polariscope.

By simultaneously adding juice, lead-subacetate solution and water, not only is a fairly intimate mixture assured, but much of the frothing is avoided; it is found that a clear filtrate is obtained by immediate filtration without waiting a few minutes as is customary in the ordinary process. The apparatus is readily cleaned when one is through using it by allowing water to run through it.

The device is easily constructed, and since the meniscus is reduced to a minimum by having the inlet of the overflow tube in the narrow neck of the pipette tube, it is, if properly calibrated, even more accurate than an ordinary pipette. The pipette has the additional advantage of delivering any quantity desired by simply adjusting the rubber stopper and outlet tube.

Care must be taken that tube *n* projects fully a half inch below the other outlet tubes as otherwise a precipitate will be formed in tube *j* which will impede the flow. The flow of water over *n* prevents the formation of a precipitate in the point. It is necessary that the juice is free from any pulp, so that the apparatus will not become clogged. We have found that press bags made of heavy drilling doubly hemmed are most serviceable and insure a clear juice. With due attention to these precautions it has been found that when one is once familiar with the apparatus, much time and labor are saved at the otherwise rather laborious routine of sugar beet analysis.

MISCELLANEOUS CHEMICAL WORK.

ROSCOE H. SHAW.

The chemical department of this Station gladly undertakes to analyze samples of agricultural products so far as our time and means permit, whenever the results of such analyses are deemed of value or interest to the agricultural public of the State. We reserve, however, in each case the right to publish these results in the annual report or in whatever way it may be considered desirable. During the year the chemist has been called upon to make analyses of feeding stuffs, fertilizing materials, lime rock, dairy salt, tobacco extract, and clam and oyster shells, as shown in the following pages.

A. *Analyses of feeding stuffs.*

No.	Name.	Name of sender.	Moisture.	Ash.	Crude protein.	Crude at.	Crude fibre.	N-free extract.
			Prct.	Prct.	Prct.	Prct.	Prct.	Prct.
1	Alfalfa hay..........	Max Grut, Cartondale, Col....................	8.77	7.68	14.19	2.09	31.22	36.05
2	Wheat bran..........	University Farm.........	10.80	5.75	17.07	4.03	11.16	54.86
3	Dried brewers grains	Chas. Linsey, La Crosse, Wis..................	8.65	4.02	27.34	7.26	14.43	62.64
4	Corn meal........ ...	University Farm.........	12.13	1.6	10.50	3.08	1.40	71.29
5	Clover hay...........	Max Grut, Cartondale. Col.....................	8.41	6.3	11.25	2.61	25.81	45.62
6	Gluten meal	University Farm.........	8.39	1.53	41.66	11.70	11.25	25.47
7	Gluten feed..........	J. M. Wagner, Hillsboro, Wis.....................	14.40	......	33.75	4.73	......	......
8	Gluten feed..........	Chas. L. Hill, Rosendale, Wis.	......	......	33.50	......	......	......
9	Chicago gluten feed.	C. V. Porter, Viroqua, Wis.....................	......	......	42.20	......	......	......
10	Hay	University Farm.........	6.82	6.85	5.02	1.65	39.85	39.81
11	Hay	O. M. Nelson, So. Superior, Wis.................	7.84	7.12	4.82	2.09	40.50	57.63
12	Ko-nut meal	India Refining Co, Philadelphia....	7.22	5.98	21.25	10.41	8.11	47.03
13	Oats..................	University Farm.........	9.69	3.30	10.80	5.03	3.11	68.07
14	Linseed oil meal.....	University Faum.........	8.23	4.74	37.00	6.87	7.40	35.76
15	Peanut meal.........	McFarland & Co., Honolulu, H. I...............	6.33	5.35	47.87	6.41	4.20	29.83
16	Peoria gluten feed...	University Farm.........	7.53	1.80	37.37	17.10	11.41	24.79
17	Corn silage..........	University Farm.........	68.27	1.60	2.80	1.90	6.53	18.90

B. *Chemical analyses of fertilizing materials.*

No.	Name.	Name of sender.	Moisture.	Nitrogen.	Phosphoric acid.	Potash
				Per ct.	Per ct.	Per ct.
1	Clam shells..........	Wisconsin Pearl Button Co., La Crosse, Wis.............	....	.3	....	....
2	Cotton refuse........	Geo. Woodruff, Janesville, Wis..........................	....	.35	.27	.9
3	Lake weeds..........	J. H. Stout, Menomonie, Wis........................	....	2.60	1 15	2 70
4	Refuse from glue factory	W. S. Glue Co................	61.53	.74	.10	....

C. *Analyses of lime rock to be used in manufacture of sugar from sugar beets.*

Number of sample.	A.	B.	C.	D.	E.	F.	G.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Moisture.........	.14	.12	.03	.12	.12	.14	....
Insoluble residue, Fe_2O_3, Al_2O_3	2.80	1.09	1.61	.67	2.45	1.45	....
Calcium carbonate	52.05	53.57	54.10	53.93	51.09	53.74	54.82
Magnesium carbonate	45.01	45.22	44.26	45.28	46.34	44.67	....
Total.....................	100.00	100.00	100.00	100.00	100.00	100 00	....

These samples, supposed to be lime stone, were analyzed to determine whether or not they were adapted for use in the manufacture of sugar from sugar beets. Of these samples A, B, C, D, E, and G were sent in by the Wisconsin Sugar Co., Menomonee Falls, Wis., and sample F by Dr. A. H. Hartwig of Watertown, Wis. In the above analyses the moisture, lime and magnesia were determined directly, the carbon dioxide calculated as being in combination with the lime and magnesia, and the insoluble matter composed of ferric oxide, alumina, silica, etc., determined by subtracting the sum of the others from 100.

The chemical composition of the seven samples varies but slightly and agrees very closely with the composition of the mineral dolomite which is a calcium-magnesium carbonate with impurities.

D. *Analyses of Dairy Salt.*

Number of sample.	A.	B.	C.
	Per ct.	Per ct	Per ct.
Moisture	.25	.14	1.50
Insoluble residue	.25	.05	.75
Calcium sulfate	.79	.65	.57
Calcium chloride	.76	.45	1.42
Magnesium chloride	.00	.00	.47
Sodium chloride	98.05	98.72	95.29
	100.00	100.00	100.00

These three samples of dairy salt were sent in by the Creamery Package Co. of Chicago. The analyses were conducted according to the method used by Prof. Woll in preparing data for his bulletin "A Study of Dairy Salt" (Wisconsin Experiment Station, Bul. No. 74). Sample B is a particularly fine grade of salt, while sample C was proven by the analysis to be an inferior grade.

E. *Analyses of tobacco extract.*

Four samples of tobacco extract were sent to the laboratory at different times during the year. These were all forwarded by Mr. L. S. Borden of Milton, Wis., who prepared them from waste tobacco.

The samples were investigated for their nicotin contents and a wide range in percentage was found. The nicotin was determined by Biel's modification of the Kissling method, with the following results:

No. 1	- - -	.55% nicotin.
No. 2	- - -	2.15% nicotin.
No. 3	- - -	1.40% nicotin.
No. 4	- - -	5.21% nicotin.

The extract was designed as a "sheep dip" or insecticide.

F. *Analyses of clam and oyster shells.*

One sample each of clam and oyster shells were analyzed to determine their respective values as a poultry food. Determinations of calcium carbonate only were made with these results:

Clam shells	- - -	94.28% calcium carbonate.
Oyster shells	- - -	95.71% calcium carbonate.

These shells can hardly be termed a food in the ordinary sense, since they serve only in the double capacity of furnishing lime for egg shells and as an aid in pulverizing the food proper in the crop. The analysis shows but little choice between them as a source of lime, but the clam shells being harder might prove the more valuable of the two for pulverizing the food in the crop.

The samples were sent in by the Wisconsin Pearl Button Co., La Crosse, Wis.

Besides the above miscellaneous work, over one hundred samples of milk and cream from different parties in the State have been tested during the year by this department.

A STUDY OF CERTAIN CONDITIONS AFFECTING THE SETTING OF FRUITS.

E. S. GOFF.

The setting of fruit blossoms, *i. e.,* the transformation from the ovary of the flower into the healthy young fruit, is one of the most obscure problems that beset the fruit grower. The conditions affecting the process are so little understood that treatment to promote the setting of the flowers is out of the question. While the failure of the majority of the flowers to set is sometimes a blessing, it is often a serious loss. The progressive fruit grower will welcome any evidence that throws light upon the subject.

The setting of the fruit results, in most cases, from the fecundation or fertilization of the ovule or ovules by the pollen. At a certain period in the history of the flower, the top of the pistil (stigma) secretes a drop of viscous liquid. A grain of fertile pollen from a stamen of the same flower, or from another flower of the same species, alighting upon the stigma at this time, if the weather is sufficiently warm, soon undergoes a change resembling the germination of a seed. A slender tube grows from the pollen grain lengthwise through the pistil and into the ovary, where it comes in contact with the ovule which is the future seed. The contents of the pollen grain are then discharged. If these contents and the ovule are perfectly developed, fecundation occurs. The ovary soon undergoes a decided enlargement and the flower stem thickens, the outer flower parts shrivel and disappear, and we have left only the young fruit.

The pollen grains are secreted by the anthers, which are the

enlarged top of the stamens. The anthers burst at maturity and set free the pollen as a yellow dust-like material that is readily blown by the wind, or that adheres to the bodies of insects that visit the flowers. As the pollen grains in normal flowers are very numerous, and as the stigma secretes a viscous liquid at the time the ovule is ripe for fecundation, the chances are greatly in favor of one or more pollen grains reaching the stigma of every flower, provided only the air is sufficiently dry and warm at the time to promote the flying of the pollen, and the visits of insects to the flowers.

Among the causes that act to prevent the setting of fruits, a few are readily apparent, such as damage to the open flowers by wind, hail, insects or fungi, or a deficient development of parts, as the lack of the pistil so common in some of the native plums.[1]

But the greater part of the flowers that fail to set fruit often appear perfectly developed. They are not visibly injured after opening, but the ovary fails to enlarge at the proper time, or enlarges but slightly; the stem shrivels and loosens its attachment to the branch, and the faded flower drops or is blown away by the passing breeze. In these cases, the failure of the flower to set is apparently due to the failure of one or more of the organs to perform their normal functions. The stigma may have failed to receive its pollen grain at the proper time, the pollen grain that found its place may not have germinated or its contents may have been infertile, or some part of the pistil may have been abnormal, and thus prevented the fecundation. Obviously, a problem subject to such a wide range of causes cannot be investigated from all sides at once. The past season,

[1] The following data were gathered from flowers of certain native plums that failed to set fruits:

Variety.	No. of flowers examined.	No. without pistil.	No. injured by insects.	No. broken by wind.	No. destroyed by fungus.	Cause not apparent.
Springer	108	7	19	21	4	57
Rollingstone	101	78	1	....	9	13
Surprise	43	12	1	2	1	30

the study was undertaken chiefly from the standpoint of the pollen grain.

INFLUENCE OF THE WEATHER UPON THE BURSTING OF THE ANTHERS.

The first step in the process of fecundation is the bursting of the anthers and the setting free of the pollen. The influence of the weather upon this process was studied with reference to (a) atmospheric moisture, and (b) temperature.

It has long been known that the bursting of the anthers is due, at least in part, to the drying and consequent contraction of their outer walls. The following experiment was conducted to ascertain to what extent, if at all, the anthers burst in a moist atmosphere.

On May 7th, two flower-bearing twigs each of the Prunus apple, George Glass cherry and a seedling native plum were cut, and all burst anthers were removed from the flowers. The cut end of one twig of each fruit was then inserted into each of two bottles containing water. One of the bottles was left exposed to the air of the laboratory, and the other was set on a ground-glass plate by the side of a small dish of water, and the whole covered with a bell-jar. The air beneath the bell-jar was saturated with moisture a part of the time, as was shown by the condensation of water on the inside of the glass.

Thus we had one twig of each of the fruits named exposed to the dry air of the laboratory, and a second to the nearly or quite saturated air beneath the bell-jar.

After fifty-six hours, practically all of the cherry anthers and a large part of the apple and plum anthers outside the bell-jar had burst, while none of those beneath the jar had burst. The temperature of the laboratory in the meantime, as indicated by a thermograph on the table, varied from 65° to 70° F. Soon after this, the bell-jar was removed from the glass plate, leaving the flowers that had thus far been covered, exposed to the dry air of the laboratory. Fourteen hours later, many of the anthers had burst, and all eventually burst.

From this experiment, we may infer that the anthers of the plants used do not burst in a very moist atmosphere. This fact

is important because it indicates that the pollen is not wasted by protracted rain, as some have suspected. So long as rain falls, so long as the trees are wet with rain or dew, or so long as they are enveloped in fog, no pollen will be discharged. Nor is the pollen likely to be discharged much in damp, cloudy weather.

In the above experiment, it was observed that the viscid secretion of the stigma, which causes the pollen to adhere to it and to germinate, remained longer in the flowers under the bell-jar than in those outside of it. This would indicate that a moist atmosphere retards the maturity of the pistils as well as of the anthers. It appeared also that the viscid secretion remained longer on the pistils of the plum than on those of the cherry.

To ascertain the effect of a low temperature upon the bursting of the anthers, two flower-bearing twigs of the Northwestern Greening apple from which all burst anthers had been removed, were connected with bottles of water through a waxed cork; and the bottles were each enclosed in a bell-jar with a dish of pure sulfuric acid to absorb all moisture from the air. One of the bell-jars was then placed in the lower chamber of a refrigerator, where the temperature, as indicated by a thermograph, varied little from 51° F., and the other was left in the laboratory, where the temperatue was about 70° F. Thus the flowers in the refrigerator were exposed to a temperature about 20 degrees lower than the others, and were also in darkness while the others were in diffused light during the day. After 24 hours, some anthers had burst in the refrigerator, but many more had burst in the laboratory. The influence of the light, however, does not appear in this experiment. But if the immediate cause of the bursting of the anthers is the drying of their outer coat, as seems quite probable, it is evident that a low temperature will retard their bursting, because it will retard their drying.

We may infer, therefore, that pollen is only discharged freely in warm and dry weather, and that a period of cool or wet weather during the blooming period tends simply to retard the bursting of the anthers and the dissemination of the pollen.

INFLUENCE OF THE WEATHER UPON THE GERMINATION OF POLLEN.

The pollen must not only find its way to the stigma of the flower, but it must germinate before it can be of service in producing fruit. How far the germination of the pollen is dependent upon weather conditions does not seem to have been determined by experiment. A series of laboratory tests was, therefore, made in the hope of throwing light on this question.

It has long been known that the pollen grains of many plants will germinate in dilute solutions of sugar. The first experiments were made to ascertain what form of sugar and what strength of solution is most favorable to the germination. Two, three, four and five per cent. solutions, respectively, of common granulated sugar, and a chemically pure sample each of cane sugar (saccharose), glucose and milk sugar (lactose) were tested. Except in the raspberry, the largest percentages of germination and the longest germination tubes were secured with the three per cent. solution of milk sugar, hence this was chiefly used in the experiments. Pollen of the Wallace raspberry, however, failed to germinate in the lactose solution, but germinated well in the saccharose solution.

In these experiments the pollen was secured by picking the flowers and placing their stems in water, for a few hours, in the laboratory. It is usually rather difficult to secure pollen from flowers in the open air, as it is soon dissipated after the bursting of the anthers. For the germination trials, a drop of the sugar solution was placed in the center of a microscope slide, and its surface touched with a burst anther with its adhering pollen grains, after which the slide was placed beneath a bell-jar to prevent the evaporation of water from the solution. As a rule, no cover glass was used on the slide.

In order to test the *influence of temperature upon the rate of germination* of pollen of the plum, cherry, apple and pear, and to ascertain at how low a temperature the pollen of these fruits is capable of germination, three slides each of the Moldavka plum (*Prunus domestica*), the Wood plum (*P. Americana*) and of the Dyehouse cherry (*P. Cerasus*) were prepared on May 7.

One slide of each variety was placed under a bell-jar in the laboratory, one of each under a bell-jar in the lower chamber of a refrigerator, and the remaining one of each was placed on a small block of wood that floated in a dish of water set in the ice chamber of the same refrigerator. Two days later these slides were examined under the microscope, and a drawing was made of a part of each slide (with one exception), by means of the camera lucida. These drawings are reproduced in Figs. 61 to 68. All illustrations of pollen are multiplied by 71.

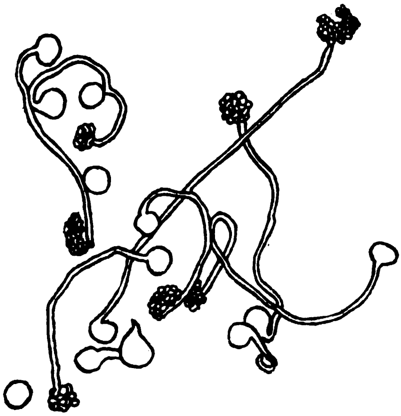


FIG. 61.—Germination of pollen of Moldavka plum, exposed two days at a temperature of 65° to 70° F.

The laboratory and the lower chamber of the refrigerator each contained a thermograph during this experiment, from which it appeared that the temperature of the laboratory fluctuated between 65° and 70° F., and that of the lower chamber varied little from 51°. The temperature of the ice chamber as determined by numerous readings varied from 39° to 40° F. From the illustrations, it is evident that the pollen of all germinated slightly at 40°, and that the pollen of the two plums germinated much more freely at 51°. The pollen of the Moldavka plum apparently germinated nearly as well at 51° as at 65° to 70°, but the contents of the grains did not seem to have been discharged as freely. The Wood plum, however, shows much longer pollen tubes when germinated at 65° to 70° than at

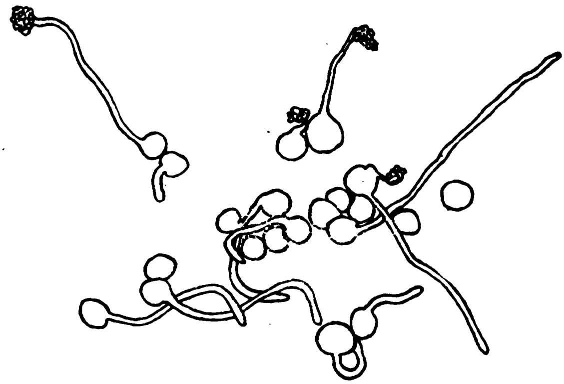


FIG. 62.—Same as Fig. 61, except that temperature was 51° F.

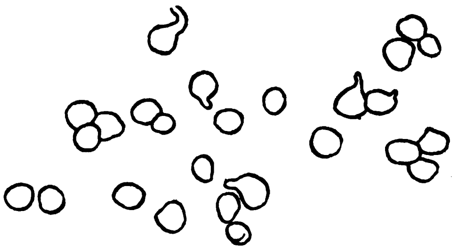


FIG. 63.—Same as Fig. 61, except that temperature was 40° F.

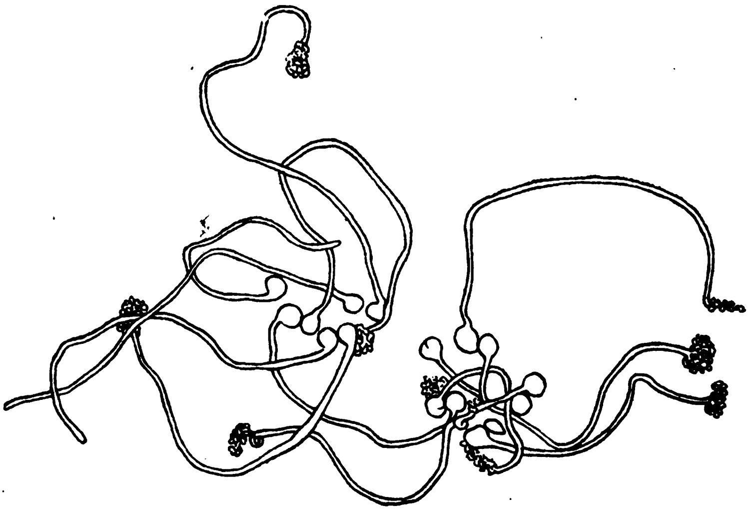


FIG. 64.—Germination of pollen of Wood plum, exposed two days at a temperature of 65° to 70° F. (All are multiplied by 65.)

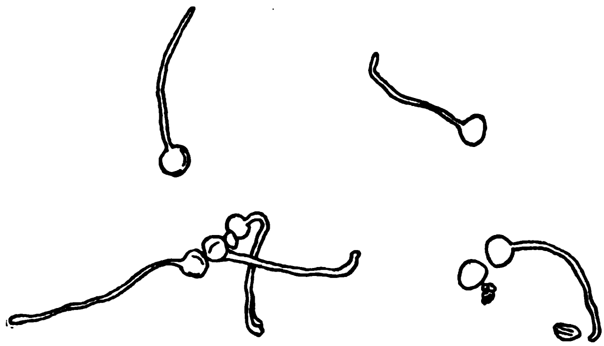


FIG. 65.—Same as Fig. 64, except that temperature was 51° F.

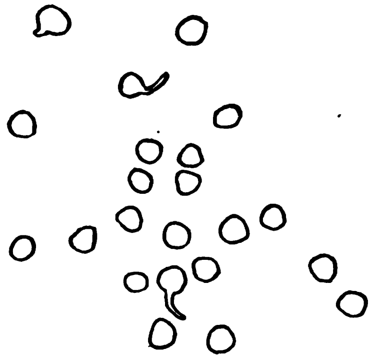


FIG. 66.—Same as Fig. 64, except that temperature was 40° F.

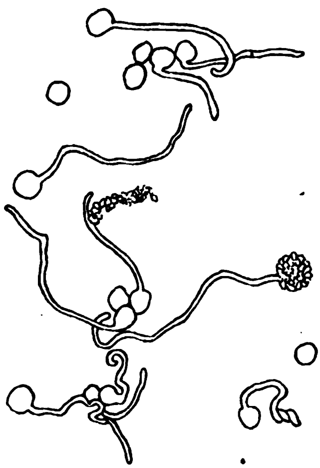


FIG. 67.—Germination of pollen of Dyehouse cherry exposed two days at temperature of 65° to 70° F.

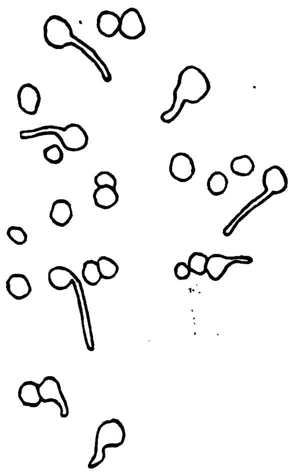


FIG. 68.—Same as Fig. 67, except that temperature was 40° F. (All are multiplied by 65.)

51°. The Dyehouse cherry germinated at the lowest temperature rather more freely than the plums. These experiments indicate that the pollen of the plum and cherry is not likely to be prevented from germination by cold at the time the flowers are open, nor is the germination likely to be much retarded until the temperature falls below 51° F.

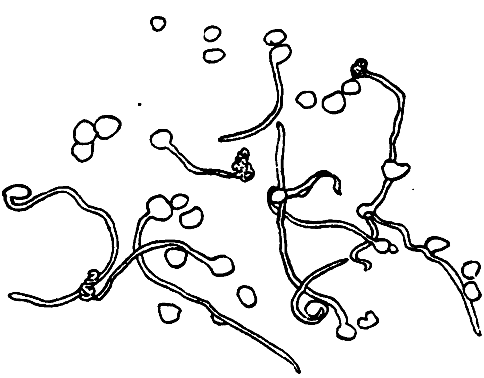


FIG. 69.—Germination of pollen of Prunus appl posed 42 hours at temperature of 65° to 70° F.

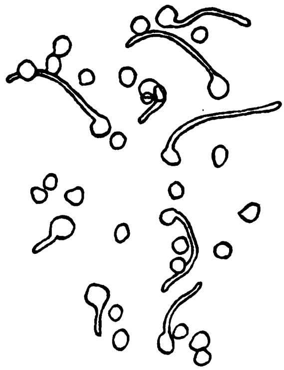


FIG. that temperature was 51° F.

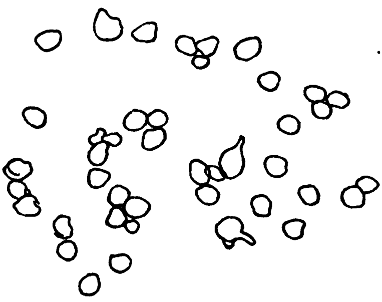


FIG. 71.—Same as Fig. 69, except that temperature was 40° F.
(All multiplied by 65.)

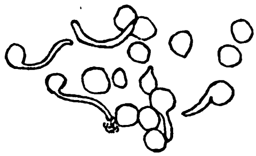


FIG. 72.—Germination of pollen of Vermont Beauty pear exposed 47 hours at temperature of 40° F.

In another trial, started May 8, pollen of the Prunus apple and Vermont Beauty pear was exposed as above noted, with the results shown in Figs. 69 to 72. As appears, the apple pollen showed a very slight germination at 40 degrees. The pear pollen, however, failed to germinate at 40 degrees, and a similar test made in 1900 also failed. Pollen of the strawberry (variety unknown) that germinated rather freely at 51 degrees also

failed to germinate at 40 degrees. At 51 degrees the pear pollen showed only a feeble germination.

To ascertain *the effect upon the germination of the pollen of prolonged exposure of the flowers to a cool, damp atmosphere,* a flower-bearing twig each of King's Amarelle cherry, Lombard plum and Wood plum was placed, with the cut end in water, in the lower chamber of the refrigerator and in the laboratory on

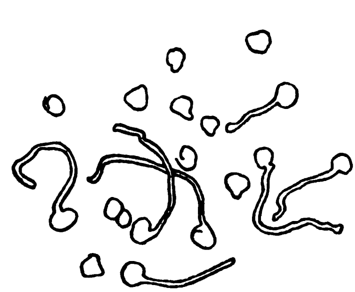


FIG. 73.—Germination of pollen of King's Amarelle cherry kept 6 days in nearly saturated atmosphere, at 51° F.

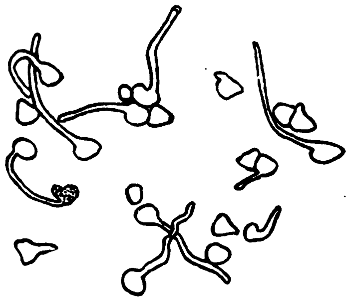


FIG. 74.—Same as Fig. 67, except that pollen was of Lombard plum.

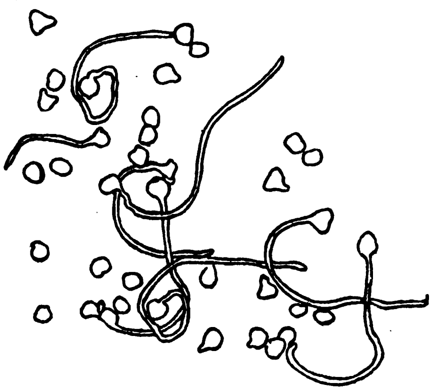


FIG. 75.—Same as Fig. 67, except that pollen was of Wood plum.
(All multiplied by 65.)

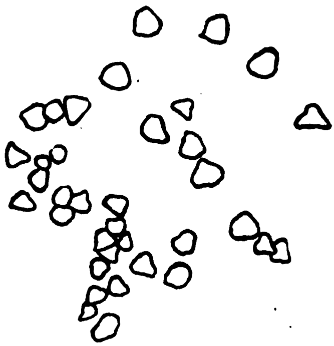


FIG. 76.—Germination of pollen of Lombard plum, kept 6 days in nearly saturated atmosphere at 65° to 70°.

May 4, both lots being covered with a bell-jar. The air was so moist beneath the bell-jar that no anthers opened, and some of the petals blighted. Late in the afternoon of May 9, the twigs were removed from the lower chamber of the refrigerator to the laboratory, and the bell-jars were removed from both lots to permit the anthers to burst. The next morning (May 10) a

slide was prepared with pollen from each of the six twigs, and placed beneath a bell-jar in the laboratory. Thirty-three hours later the pollen from the twigs that had been in the lower chamber of the refrigerator had germinated rather freely, as appears from Figs. 73, 74 and 75, while none of that kept in the laboratory had germinated. Fig. 76 shows a sample of pollen of the Lombard plum that had been kept in the laboratory, from which it appears that the grains swelled as freely as those from the refrigerator.

From this experiment, we may infer that a prolonged rainy period during the blooming season is not likely to injure the vitality of the pollen if the weather remains cool, or in the neighborhood of 50 degrees, but that it may destroy its vitality if it is as warm as 65 to 70 degrees.

Several experiments were made to determine *the influence of exposure of pollen to frost upon its germination.* These were but partially satisfactory, as in the principal trial, which included pollen of the apple, plum, and cherry, the pollen, for some unknown reason, failed to germinate well when not exposed to the frost. The fact was brought out, however, that pollen of the plum, cherry and raspberry is not necessarily destroyed by a short exposure to a temperature several degrees below the freezing point.

These experiments were conducted by means of an ice-cream freezer, of which the chamber was lined with thick paper to retard the changes of temperature. Flower-bearing twigs were first placed in the lower chamber of a refrigerator to partially cool them; from this they were transferred to the chamber of the ice-cream freezer, in which the temperature was indicated by a thermometer inserted through a hole in the lid. The time required for the temperature to fall to the freezing point after the flowers were put in the chamber varied in different trials from 4 to 16 minutes. Different samples of the flowers were exposed to temperatures varying from +3° to —5° Centigrade (about 38° to 23° F.), each sample being removed from the chamber when the temperature had fallen to the desired point.

Figs. 77 and 78 show germinated pollen grains of the plum and cherry that had been exposed to a temperature of —2° C.

(about 28° F.), and Fig. 79 shows germinated pollen of the Wallace raspberry that had been exposed to —5° C. (about 23° F). Strange to say, the pollen of the raspberry thus exposed appeared to germinate as well as that of the check sample that was exposed only to the ordinary temperature. The whole flower head drooped after the exposure.

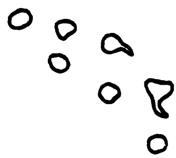


FIG. 77.—Germination of pollen of Seedling plum after being exposed to temperature of 28° F.

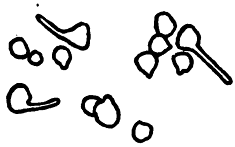


FIG. 78.—Same as Fig. 77, except that pollen was of Geo. Glass cherry.

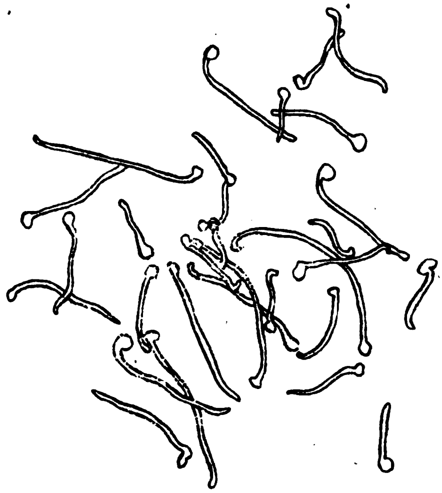


FIG. 79.—Germination of pollen of Wallace raspberry after being exposed to temperature of 23° F.

(All multiplied by 65.)

The subject of *the vitality of pollen grains* is interesting, but it is difficult to study since we are never sure that our solution used for the germination test is as favorable to the germination as the liquid furnished by the stigma of the flowers. The fact that different solutions show varying results raises the question if any of them are really good. In our trials the percentage of germinating pollen grains has usually been quite small. There are indications, however, that different samples of pollen vary much in vitality. In the spring of 1900, several samples of pollen of the Smith's Red plum failed entirely to germinate in the solution in which other plum pollen germinated fairly well. Fig. 80 shows a sample of pollen of the Virginia crab apple in which a considerable part of the grains failed to swell, which would indicate that they were not all equally capable of germination. Much more data are needed before we can arrive at definite conclusions on this subject.

Influence of the vigor of the tree upon the setting of the fruit.—Does rapid growth in cherry trees favor or hinder the setting of the fruit? The fruit spurs in the cherry almost always terminate in a leaf bud. This bud usually resumes growth about the time the flowers open, and if the tree is vigorous, the young shoot is growing rapidly during the fruit-setting period.

FIG 80.—Pollen of Virginia crab apple, showing irregularity in swelling of pollen grains.

To ascertain the influence of the rate of growth of this shoot upon the setting of fruit upon the spur whence it grows, a large number of fruit spurs were examined with reference to the proportion of flowers that set and the growth of the terminal shoot. The loose flowers and fruits were picked from the spurs, after which the spurs were examined with a pocket lens and the scars whence the flowers had fallen were counted. The set fruits were also counted. The results are condensed in the following table:

	Whole number of flowers.	Per cent. failed.
Bessarabian—Terminal growth from spur one inch or less ...	1,233	83.8
Bessarabian—Terminal growth from spur more than one inch.	578	84.6
Late Morello—Growth one inch or less.	324	79.3
Late Morello—Growth more than one inch.	240	79 1
King's Amarelle—Growth one inch or less.	445	65.2
King's Amarelle—Growth more than one inch.	198	57.1

From the above figures, we must infer that growth from the terminal bud of the fruit spur did not prevent the setting of the fruit.

CAUSE FOR THE FAILURE OF THE PISTIL IN NATIVE PLUMS.

That the flowers of the native plums are often without pistils has been frequently noted. A study of the subject made at different times at this Station has shown that the proportion of flowers without pistils varies much in different varieties and in the same variety in different seasons; also that the pistil may fail at different stages in the development of the flower. In some flowers, no pistil is visible at the time of the opening of the petals; in others, the very small pistil is visible at the bottom of the calyx tube.

A reason that has been suggested for the failure of the pistil, is, in effect, that the tree is often unable to develop a large crop of fruit and to produce at the same time a crop of vigorous flowers for the next season's crop. As a result of this overworking of the tree, the pistil of a part of the flowers fails. This reason does not, however, satisfy the facts. The blossoms of other fruits that overbear often, as the European plum and the apple, are rarely without pistils, while certain varieties of the native plum, though blooming freely every spring, never have enough pistils in their flowers to produce a large crop of fruit. Observation also showed that on individual trees, the flowers on branches that overbore the preceding season contained quite as large a proportion of pistils as those on other branches that did not overbear.

Our orchard contains a plum tree of an unknown variety of the Americana species, of which the flowers have always contained a very small percentage of pistils at the time of blooming. Examination of a large number of flower buds of this variety during autumn, winter and early spring has shown that the pistil is apparently always present. It must fail, therefore, after the commencement of mild weather in spring, and the failure is doubtless due to cold after the buds have become excited by warm weather. While the pistils of the Americana plums are able to endure very severe winter weather, they are liable to be, in part, destroyed by a return of cold weather after unseasonable warm weather in spring. It rarely happens, however, that the proportion of pistils thus destroyed, in our best varieties, is large enough to prevent a good crop of fruit.

SUMMARY OF THE PRECEDING ARTICLE.

The anthers of one variety each of the apple, cherry, and plum failed to burst under a bell-jar, where the air was nearly or quite saturated. We may infer from this that the pollen of these fruits will not be discharged much during a rain storm, or while the trees are wet with rain or are enveloped in fog.

Anthers of one variety of the apple did not burst freely in a very dry atmosphere at a temperature of 51° F.

Pollen of the Moldavka and Wood plums, the Dyehouse cherry and the Prunus apple germinated slightly at a temperature of 40° F., but that of the two plums germinated much more freely at 51°. Pollen of the Moldavka plum germinated nearly as freely at 51° as at 65° to 70°. Pollen of the Vermont Beauty pear and of an unknown variety of strawberry failed to germinate at 40° F. that germinated at 51°.

Pollen of two varieties of plum and one of cherry, confined five days at a temperature of 65° to 70° F. beneath a bell-jar where the air was nearly saturated, failed to germinate, while pollen of the same varieties confined in the same way, but at a temperature of 51°, germinated rather freely. We may infer from this that a prolonged rainy period during bloom is not likely to injure the vitality of pollen so long as the weather remains cool.

Pollen of the plum and cherry germinated slightly after having been exposed to a temperature of 4° F. below freezing and that of the Wallace raspberry germinated freely after having been exposed to 9° below freezing.

The fruit spurs in the cherry that made the largest growth during the fruit setting period, set fruits for about as large a percentage of their flowers as those that made less than one inch of growth, from which we may infer that vigorous growth in the cherry tree does not necessarily interfere with the setting of the fruit.

The failure of the pistil in flowers of the native plum is probably due, in the majority of cases, to a return of cold weather after the buds have become excited in spring.

INVESTIGATION OF FLOWER-BUDS.

E. S. GOFF.

The study of the early stages of flower formation in our fruit plants, commenced in the summer of 1899 and pursued through the season of 1900, has been continued, as time permitted, the past season. Some of the questions to which answer was sought the past season were the following:

1st, the time of flower formation in the currant, gooseberry and cranberry; 2nd, the variation in the period of flower formation between different varieties of the apple growing in the same orchard; 3rd, the influence of irrigation upon the formation of flower-buds in the apple in time of drought, and 4th, the extent to which flowers are formed the season before their expansion in those fruit plants in which no flower-buds can be distinguished in autumn.

I. THE TIME OF FLOWER FORMATION IN THE CURRANT, GOOSEBERRY AND CRANBERRY.

In these fruits the effort was made to ascertain the date at which the flowers commenced to be visible, and also the development to which they attained before the close of the season.

The Currant.—Fig. 81 shows a section of a bud of the Pomona currant. The bud was taken from the bush July 8. The thickened crown with its undulating border shows that the flowers were just beginning to appear at that time. Fig. 82 shows an outline drawing of a section of a bud of the White-Grape currant, for which the bud was taken Oct. 30. The

[1] For detailed report of these studies see Report of this Station for 1899, pp. 289-303, and 1900, pp. 266-285.

flowers of the raceme appear much crowded, but show little differentiation into parts. Fig. 83 shows the central part of a section of a bud of the Black Victoria currant, for which the bud was taken Aug. 3. It is apparent that the flowers are just beginning to form.

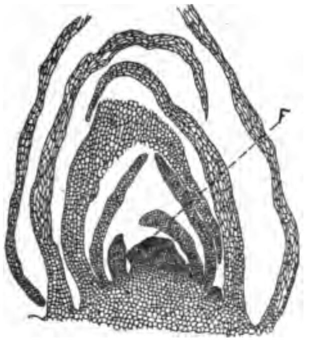


FIG. 81.- Vertical section from bud of Pomona currant taken July 8. F, incipient flowers. (x 33).

FIG. 82.—Vertical section from bud of White Grape currant taken Oct. 30. (x 33).

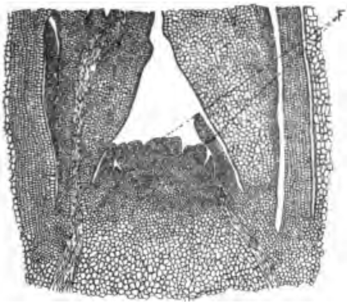


FIG. 83.—Vertical section from bud of Black Victoria currant taken Aug. 3. F, incipient flowers. (x 33).

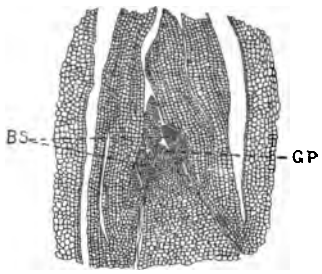


FIG. 84.—Vertical section from bud of Downing gooseberry taken Aug. 30 No indications of flowers are apparent. G P, growing point; B S, embryo leaves. (x 33).

The Gooseberry.—Figs 84 and 85 show sections of two buds of the Downing gooseberry, for which the buds were taken Aug. 30. The bud shown in Fig. 84 evidently had not yet commenced to form flowers. The other shows the flowers well started. Fig. 86 shows a section of a bud of the same variety of gooseberry for which the bud was taken Oct. 20, 1899. The

ovules had apparently commenced to form in one of the flowers shown in this illustration. (0 in the figure.) This is one of a very few instances thus far observed where the ovules are formed in autumn.

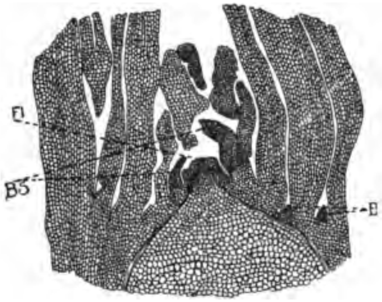


FIG. 85.—Same as Fig. 84. Fl, incipient flower; B, axillary buds. (x 33).

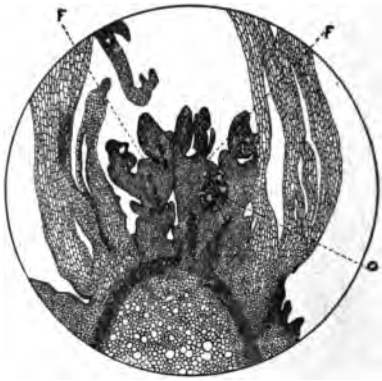


FIG. 86.—Same as Fig. 84, from bud taken Oct. 20 1899. F F, flowers, o, ovules. (x 20.)

Since the weather during the part of the past season in which the flowers were beginning to form in the above plants was unusually dry and warm, it is impossible to say how far the dates named are to be taken as the normal period of flower formation for these plants. We may presume, however, that the dates are not later than usual, since the tendency of hot and dry weather is to hasten the blooming period of plants.

The Cranberry.—Certain members of the Wisconsin State Cranberry Growers' Association made a formal request, during the past winter, that the time of formation of flowers in the cranberry plant be investigated at our Station. They made this request because they were in doubt as to whether their treatment of their cranberry marshes during summer was best, and they felt that the knowledge of the time of formation of the flowers would help them in formulating a method of treatment. Mr. W. H. Fitch, of Cranmoor, Wis., secretary of the association, volunteered to send material from a bearing cranberry marsh each week during the summer to aid in this investigation. The material came regularly, with a few slight exceptions, and generally arrived in excellent condition.

The first sample came to hand June 1, and was immediately prepared for examination under the microscope. Fig. 87 shows a longitudinal section through the tip of one of the growing shoots of this sample, multiplied about 45 times. The growing point, where the leaves and buds have their origin, is pointed out by the dotted line from A. In like manner, B points out the young leaves that are in process of unfolding from the growing point. On either side are shown parts of two more-expanded leaves, and in the axil of the outer one of each pair, indicated by C, appears a young axillary bud, destined to remain dormant until the following spring, when it might have developed into a "runner."

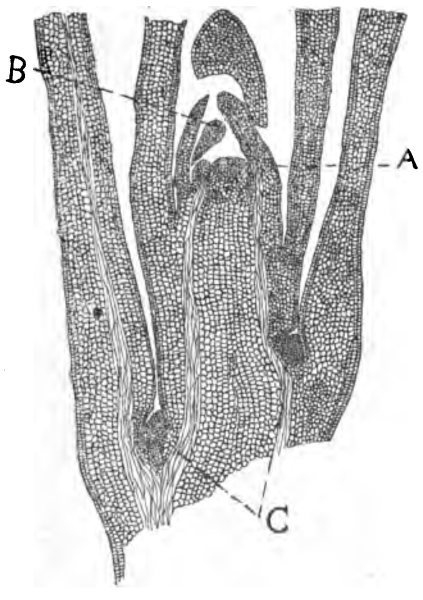


FIG 87.—Vertical section from bud of cranberry taken June 1. A, growing point; B, embryo leaf; C, axillary bud. (x 45.)

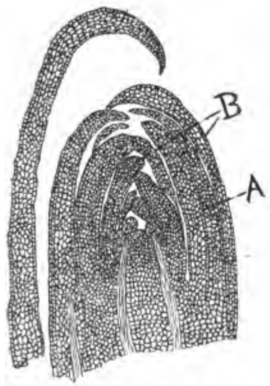


FIG. 88.—Same as Fig. 87, from bud taken July 27.

Other buds that came from time to time after June 1 were examined, but no marked change appeared until the latter part of July, when it was evident that, although new embryo leaves continued to form at the growing point, the stem elongated less rapidly, and the young leaves showed less disposition to straighten out. Fig. 88 shows a longitudinal section through the

apex of a shoot received July 27. The growing point is indicated at A as before, and the young leaves about it are shown by B. Note the large number of undeveloped leaves as compared with those in the preceding figure. This shows that the stem just behind the growing point has nearly ceased to grow, and is an indication that the so-called terminal bud would soon have formed. At this time, however, the apex of the stem was very small, having scarcely as yet commenced to swell. During August there was a gradual thickening of the apex of the stems, but no clear indication of flowers could be found, until some buds received Sept. 16 were sectioned. A section of one of these buds is shown, multiplied by 45, in Fig. 89.

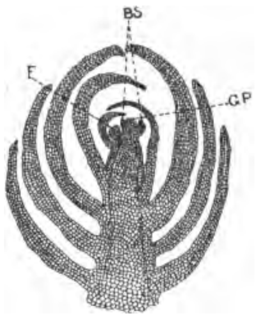


FIG. 89.—Same as Fig. 87, from bud taken Sept. 16. G P, growing points; B S, incipient leaves; F, incipient flower. (x 45.)

Comparing this illustration with the preceding one, a marked increase in size is noticeable, and also the tendency of the younger embryo leaves to curve outward at the center. But the most radical change is that shown in the vicinity of the growing point. In the axils of one of the youngest embryo leaves appears a protuberance (F), quite different in form and position from anything we have seen heretofore. From its location, and its close resemblance to the embryo flowers of other plants, there can be no question that this is an embryo flower. The last buds received prior to this sample came to hand August 31, and no indications of flowers could be found in these. Had another sample been received intermediate between these two, we might possibly have detected the flower formation at

an earlier stage. We know, however, that the plants whence these buds came began to form flowers during the first half of September, which is sufficient for our present purpose. A study of the flower-forming period in other fruit plants has shown that the development of the flowers is quite rapid for a time after they start. It is quite possible that the visible flower growth shown in Fig. 89 may all have occurred during the week preceding the taking of the sample.

The question may be asked, why only one flower is apparent, when several flowers usually open from one terminal bud? The illustration shows only a thin section through the center of the bud, but the flowers are distributed around the stem of the bud somewhat as the eyes are distributed over the surface of a potato. It would, of course, be impossible to make a thin slice lengthwise through a potato that would dissect all of the eyes, and it is no more possible to show all of the flowers in a bud on a single section.

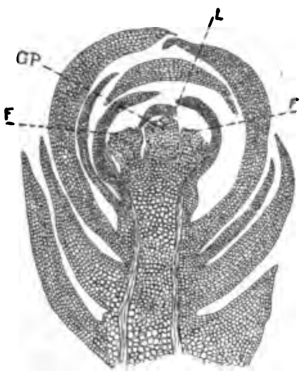


FIG. 90.—Same as Fig. 87, from bud taken Oct. 2. G P, growing point; L, incipient leaves; F, flowers. (x 45).

FIG. 91.—Same as Fig. 87, (outline), from bud taken Oct. 10. (x 45).

Some buds received Oct. 2 were sectioned to ascertain how much growth, if any, had occurred in the flowers after Sept. 16. As appears from Fig. 90 the flowers appear to have advanced slightly between Sept. 16 and Oct. 2. Fig. 91 shows a section through a bud received Oct. 10, which also shows a slight advancement in the flowers over those received Oct. 2. The calyx and petals are more readily discerned.

It would be unsafe to conclude that the flowers of all varieties of the cranberry begin to form every year during the first half of September. They may form earlier or later in some varieties and in some seasons. It is hoped that the observations may be repeated the coming season.

II. THE VARIATION IN THE PERIOD OF FLOWER FORMATION BETWEEN DIFFERENT VARIETIES OF APPLE IN THE SAME ORCHARD.

Our investigation in the summer of 1899 showed that the embryo flowers began to be visible in one variety of apple (the Hoadley) as early as June 30; further investigation in 1900 gave excellent evidence that many flowers on that same tree formed after September 1, 1899. The latter investigation also showed that on certain trees the flowers continued to form until checked by cold weather.

The past season, the attempt was made to ascertain to what extent the period of flower formation is a regular one for all varieties of the apple. We know that the period of flower expansion in spring does not vary much between varieties, and that trees of many varieties in an orchard are commonly in full bloom during the same week. It is easy to infer from this, that there is a period during summer when the flowers are forming rapidly in nearly all bearing trees of the same fruit at once.

The investigation here reported was made upon trees in our Station orchard that had borne fruit in one or more previous seasons. It was made by examining from time to time a few buds on the different trees that seemed most likely, from their location and appearance, to become flower-buds. If these buds contained no flowers, it was assumed that the tree whence they came had not yet entered the flower-forming period. Figs. 92 and 93 show outline drawings of longitudinal sections through buds of two varieties of the apple, in which the embryo flowers are just beginning to appear. If these sections are compared with other sections through a leaf-bud, the protuberances at the apex of the bud stem cannot be mistaken for embryo leaves, and other buds that show later development of the flowers will remove any possible doubts on the subject.

The past season was very warm and dry from the middle of June until September, and this fact doubtless influenced the formation of flowers in our orchard. Out of 114 varieties examined, only 40 appeared to have any embryo flowers in their buds at the beginning of October. Five of these 40 varieties, viz., Crimea Bog, Getman, Gideon, Gros Mogul, and an unnamed seedling had formed many flowers prior to August 1st; two of them, on the other hand, viz., Crampton's No. 3 and Hazenkopt did not form flowers until after September 3rd. The buds of Crampton's No. 3 had been examined twice, and those of Hazenkopt three times, before any flowers were found. The other 33 varieties of the 40 apparently began to form their flowers some time between Aug. 1st and Sept. 3rd.

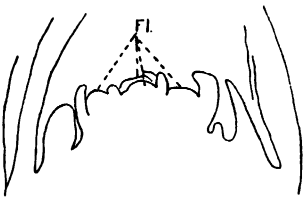


FIG. 92.

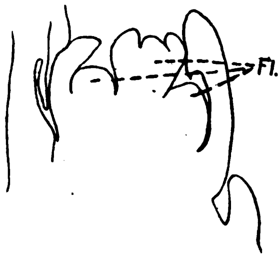


FIG. 93.

Vertical sections through a flower-bud of the Getman, and of a seedling apple, respectively. Fl, flowers. (x 22).

About Sept. 10 a bountiful rain came. Although several weeks of warm weather followed, no varieties appeared to commence the formation of flowers after this rain. We must infer, therefore, that during the past summer, there was no well-marked flower-forming period among the apples that formed flowers in our Station orchard, or at least that different varieties began to form their flowers through a period five weeks or more long.

While we hope to give this subject further investigation, the evidence gained during the past two seasons points strongly to the conclusion that a bearing apple tree may begin to form flowers at any time after growth ceases until toward the middle of September, or it may not begin at all.

III. THE INFLUENCE OF IRRIGATION UPON THE FORMATION OF FLOWER-BUDS IN TIME OF DROUGHT.

This experiment was made upon two Gideon apple trees of the same age, and apparently uniform in condition. Both were planted in 1891 and have received the same treatment since; they stand 48 feet apart. The soil about them was in grass during the season of 1900, but was plowed about June 1st the past season. On June 12 two barrels of water were applied to the soil about one of the trees, by pouring it into shallow holes dug in a circle a few feet from the trunk, and a similar watering was given each week, with one exception, until the middle of August. At least sixteen barrels of water were given this tree and it was so put on that none of it flowed away, unless by sinking downward. The other tree received no artificial watering and only 3.98 inches of rain fell during the period that the first tree was watered. A considerable part of this rainfall came in small showers that failed to wet the soil to the depth of an inch. The foliage of the watered tree was perceptibly fresher after the watering commenced than that of the other, and the growth of it was a little stronger, but the difference was less than was expected. The buds on both of the trees were examined for flowers on July 12, 23, and 31, but no flowers were found on either tree, though at the last examination both trees showed symptoms of flowers. On August 9, both of the trees had flowers in all of the buds examined. The difference in their advancement was slight, but the little was in favor of the not-watered tree.

Wishing to ascertain the difference, if any, in the percentage of flower-buds formed on the fruit spurs on the two trees, 100 buds were taken from the spurs of each tree, Oct. 16 to 18, and weighed, after which they were examined under the microscope. The 100 buds from the watered tree weighed 10.1 grammes, while those from the not-watered tree weighed 13.138 grammes. Eighty-nine buds out of each lot contained flowers.

The growth beneath the buds on the fruit spurs was, on the average, at least twice as much on the watered tree as on the other, but the number of swelled buds on the spurs was perceptibly greater on the not-watered tree.

It is noted above that only 89 per cent. of the swelled buds examined on the fruit spurs of these two trees contained flowers. It was repeatedly observed, the past season, that we cannot say with certainty that any given bud on the apple tree contains flowers without dissecting it. The plumpest buds of all are commonly the terminal buds of the shoots, and these rarely contain flowers. But cases were occasionally found where the plumpest buds on a fruit spur were without flowers while a less plump one had formed them. Between different varieties, it is unsafe to judge without dissecting sample buds which of two may contain the more flowers. These facts do not, however, prevent the observing apple grower from forming, during autumn or winter, a fairly accurate conclusion as to the amount of bloom he may expect the next spring.

It is of interest that the abundant watering given the watered tree, in a period of extreme drought and heat, did not perceptibly affect the time of the appearance of the first flowers, although these did not appear until about eight weeks after the watering had commenced. Nor did the watering perceptibly affect the percentage of the swelled buds that formed flowers. It did, however, seem to affect perceptibly the percentage of buds that swelled, and also the amount of growth beneath the buds on the fruit spurs. The tree that was not watered promises to bear the better crop next year.

IV. ARE THE FLOWERS FORMED THE SEASON PRIOR TO THEIR EXPANSION IN THOSE FRUIT PLANTS IN WHICH WE CAN DISTINGUISH NO FLOWER-BUDS IN AUTUMN.

In some of our fruit plants, as the apple, pear, peach, plum, and cherry, the buds that contain flowers can be distinguished from their appearance or location, with some degree of certainty, the autumn before their expansion. In others, as the quince, raspberry, blackberry, and grape, no such flower-buds can be distinguished. It is of interest to know whether the flowers in this latter class of fruit plants are formed the season prior to their expansion, or in spring, after growth commences.

In the common quince (*Cydonia vulgaris*) the flowers are solitary at the ends of leafy shoots. The buds that are to flower in spring are little if any larger the preceding autumn than others. As appears from Fig. 94, however, the embryo flowers are present in autumn in the buds that are to flower in spring. Since there is only one flower in a place, and that is but little developed in autumn, the flower-buds are not conspicuously different from other buds on the same plant, but it is probable that they may be made out, in part at least, by close examination.

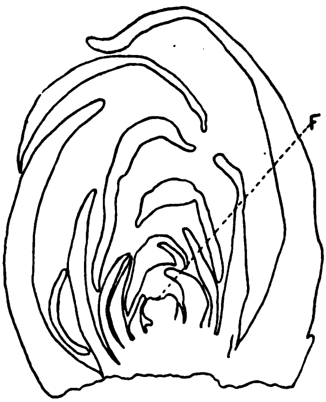


FIG. 94.—Vertical section through bud of Champion quince, cut late in the autumn. F, incipient flower. (x 20).

The most conspicuous difference between the flowering habit of the quince and that of the apple is that the flowers in the quince are borne singly. In the apple, as in the quince, the flowers are borne at the end of a leafy shoot, but the internodes of this shoot are commonly less elongated than in the quince.

In the raspberry and blackberry, the buds that form in the axils of the leaves of the young shoots contain a whole branch in embryo—often several nodes, with a leaf at each node. The bud at the apex of this branch and the axillary buds along it, if they form, are flower-buds. As appears from Figs. 95 and 96, embryo flowers in these buds are formed the season before their expansion, at least in part.

In the grape, the bud that forms near the axil of a leaf on the young shoot, contains, as in the raspberry and blackberry, a shoot in embryo, but in the grape the terminal bud does not form flowers. The axillary buds of this shoot, however, do form flow-

FIG. 95.—Vertical section from bud of Wallace raspberry, taken late in autumn. F, incipient flower. (x 20).

ers. In this respect the grape resembles the cranberry. An examination made in the autumn of 1899 showed that these embryo flowers were also discernible in autumn.

If our theory that an abundant supply of water and the consequent rapid growth are opposed to the formation of flowers, is

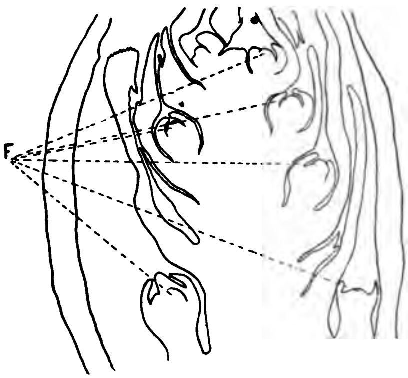


FIG. 96.—Same as Fig. 89, from bud of Bonanza raspberry. (x 20).

correct, it is difficult to comprehend how flowers can be formed in woody plants in early spring, for the wood is certainly more gorged with water in the early spring than in any other part of the growing season.

SUMMARY OF THE PRECEDING ARTICLE.

Buds of the Pomona currant taken July 8 showed a very early stage of flower formation; those of the Black Victoria currant taken Aug. 3 showed the flowers just beginning to form; those of Downing gooseberry taken Aug. 30 showed flowers well advanced. Buds of the latter taken Oct. 20, 1899, showed ovules. Buds of the cranberry taken Aug. 31 showed no positive evidence of flowers, while the samples taken Sept. 16 showed flowers well started. The flowers showed some development after Oct. 2.

Flowers commenced to form in different varieties of the apple at various times from prior to Aug. 1 to Sept. 3rd. After the plentiful rains which began about Sept. 10, no varieties appeared to commence the formation of flowers.

The application of two barrels of water per week to a tree of the Gideon apple, during a severe drought did not, apparently, cause it to form flowers either earlier or later than on a check tree that received no artificial watering; nor did it change the percentage of the buds on the fruit spurs that formed flowers. It did appear, however, to reduce the size of the flower-buds, and also the total number.

Flowers are unquestionably formed the season previous to their expansion in the quince, raspberry, blackberry, and grape, notwithstanding the fact that no flower-buds can be distinguished in autumn in these plants.

THIRD REPORT ON EXPERIMENT IN PINCHING RASPBERRY SHOOTS.

F. CRANEFIELD.

In the spring of 1897 eighteen rows of raspberries were planted for the purpose of observing the influence of pinching the growing shoots on the yield of fruit and the growth of the plants. The plants were set four feet apart, in rows seven feet apart. Nine rows of Gregg and nine of Cuthbert were planted.

The plan of the experiment as outlined by Prof. Goff in the last Annual Report of this Station follows:

"For the experiment, the plat of each variety was divided into three smaller plats, each of which contained three rows. Each of these three-row plats had one row that was left unpinched, one row of which the shoots only were pinched, and one row in which both the shoots and laterals were pinched. In the first plat of each variety, the shoots of the pinched rows were pinched as fast as they attained the height of 12 inches; in the second plat they were pinched as fast as they attained the height of 18 inches, and in the third plat, as they attained the height of 24 inches. The laterals were pinched as they attained a length of 12 inches."

Until 1899 four shoots to a plant were allowed to grow, but for the past two seasons five shoots to a plant were retained.

The plantation has been well cultivated each year during the growing season and the plants have been covered with earth each winter. A dressing of well-rotted manure was applied during the winter of 1900–1.

The extraordinary heat and drought of the past season seriously affected the yield of fruit, reducing it to less than one-half that of the previous season.

The data covering the yield of fruit, etc., are given in the following table, in connection with an average of the two preceding crops. In the third and fourth columns will be found the actual yield of fruit in ounces and the yield calculated to 36 plants to a row. The average yield for three seasons is given in the right-hand column in bold face type:

Table showing the effect of pinching the shoots on the yield of fruit.

	Number of plants.	Number of canes.	Actual yield, 1901.	Yield calculated to 36 plants, 1901.	Average for 3 crops.
GREGG.			Ounces.	Ounces.	Ounces.
Shoots not pinched....	36	134	418.3	418.3	**1,124.0**
Shoots pinched at 12 in	34	128	419.1	442.8	**924.4**
Shoots pinched at 12 in., laterals pinched at 12 in.	35	135	476.2	478.8	**1,158.0**
Shoots not pinched.................	36	135	500.7	500.7	**951.3**
Shoots pinched at 18 in............	35	135	631.9	648.0	**1,347.6**
Shoots pinched at 18 in., laterals pinched at 12 in....	37	162	633.5	615.6	**1,231.4**
Shoots not pinched.................	35	138	391.5	399.6	**1,119.6**
Shoots pinched at 24 in.............	37	154	503.7	489.6	**1,514.4**
Shoots pinched at 24 in., laterals pinched at 12 in..................	36	157	665.4	665.4	**1,379.0**
CUTHBERT.					
Shoots not pinched................	36	153	133.2	133.2	**1,161.2**
Shoots pinched at 12 in.............	38	158	102.6	97.9	**991.5**
Shoots pinched at 12 in., laterals pinched at 12 in...........	36	161	105.3	105.3	**1,007.4**
Shoots not pinched.................	35	149	118.6	120.9	**1,152.9**
Shoots pinched at 18 in.............	37	154	94.5	91.4	**1,013.3**
Shoots pinched at 18 in., laterals pinched at 12 in..................		154	121.1	121.1	**1,072.5**
Shoots not pinched.................	36	157	139.2	139.2	**750.8**
Shoots pinched at 24 in.............	36	151	117.0	117.0	**1,073.8**
Shoots pinched at 24 in., laterals pinched at 12 in..................	36	161	101.3	101.3	**812.2**

Considering the average for three seasons, it may be seen that the two largest yields in the case of the Gregg were from the two rows pinched at 24 inches, and the third largest yield was from the row pinched once at 18 inches.

In the Cuthbert the two largest yields were from the rows not pinched and the third largest from the row pinched once at 24 inches.

The average of the three not-pinched rows of Gregg is 1065 ounces, of the three rows pinched once 1262 ounces, and of the three rows pinched twice 1256 ounces.

The average of the three not-pinched rows of Cuthbert is 1021.6 ounces, of the three rows pinched once 1026.2 ounces and of the rows pinched twice 964.0 ounces.

Effect of pinching on the growth of shoots and suckers: All superfluous shoots and suckers were removed from time to time during the growing season and weighed. In the following table is shown the amount in ounces for three years, as well as the average of all of the rows pinched in different ways and those not pinched:

Table showing the effect of pinching on the growth of superfluous shoots and suckers.

GREGG.	1899.			1900.			1901.		
	Pinched twice.	Pinched once.	Not pinched.	Pinched twice.	Pinched once.	Not pinched.	Pinched twice.	Pinched once.	Not pinched
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.
Pinched at 12 inches.......	259.0	241.4	191.0	76.25	70.75	56.5	159.5	93.5	236.0
Pinched at 18 inches	237.0	282.8	238.2	61.75	48.0	39.25	198.2	97.5	205.3
Pinched at 24 inches.......	282.0	213.8	186 5	103.5	51.75	61.75	223.5	150.5	186.7
Average...	259.3+	246.0	205.2+	80.5	56.8+	52.5	193 7+	113.8+	186.6+
CUTHBERT.									
Pinched at 12 inches.......	924.0	1,071.5	803.0	179.5	144.75	192.25	272.0	293.3	288.2
Pinched at 18 inches.......	884.0	993.6	936.0	173.25	197.0	195.5	387.0	429.1	197.4
Pinched at 24 inches.....	595.5	751.0	686.9	163.5	173.75	230.75	260.6	318.2	503.4
Average...	801.2−	939.7	808.6+	172.08+	171.83+	206.16+	306.5+	346.8+	329.6+

Computing from this table, the average results of the three seasons we have the following:

Gregg.—Pinched twice, 533.5 ounces; pinched once, 416.6; not pinched, 444.3 ounces.

Cuthbert.—Pinched twice, 1279.3 ounces; pinched once, 1458.3; not pinched, 1344.3 ounces.

Summary.—From the data here given it appears that high pinching (at 18 and 24 inches) increased the yield of the Gregg raspberry and decreased the yield of the Cuthbert.

Low pinching (at 12 inches) appears to have decreased the yield in both cases.

Pinching has increased the production of shoots of the Gregg and decreased the production of both shoots and suckers in the Cuthbert.

It is intended to continue this experiment for at least two more years.

EXPERIMENTS IN SUB-IRRIGATION OF FLOWER BEDS.

F. CRANEFIELD.

Flowering and foliage plants when set in beds rarely receive sufficient water for their fullest development. The plants are usually set so closely together that the roots quickly exhaust the moisture from the soil and also prevent, in a large measure, cultivation of the surface soil. In many cases the beds are raised more or less above the surrounding lawn so that instead of retaining more water from rains than the adjacent grass, they usually retain far less. Under such conditions flower beds require frequent and thorough watering in order to obtain the best results.

Sub-irrigation for flower beds has been successfully employed on the Station grounds for the past six years. The first experiment in this line was described in the 13th Annual Report of this Station (pp. 256–259) and is here briefly reviewed.

A circular bed 22 feet in diameter was excavated to a depth of 16 inches and a system of three-inch drain tile laid on the (clay) bottom, as indicated in the diagram (Fig. 97). The main line was closed at one end and connected with a vertical tile at the other to serve as an inlet. The branch lines were laid one foot apart and the outer end of each line was closed with a brick. The bed, when refilled, was planted with Castor Beans, Cannas, Caladiums, Coleuses and Geraniums. The bed was watered five times during the season, about fifty barrels of water being applied each time, by means of a two and one-half inch stream under slight pressure. The results were highly satisfactory so far as the growth of the plants was concerned.

The following year three smaller beds on the lawn were arranged for sub-irrigation in a similar manner and, as with the larger bed, have proved in a large measure satisfactory.

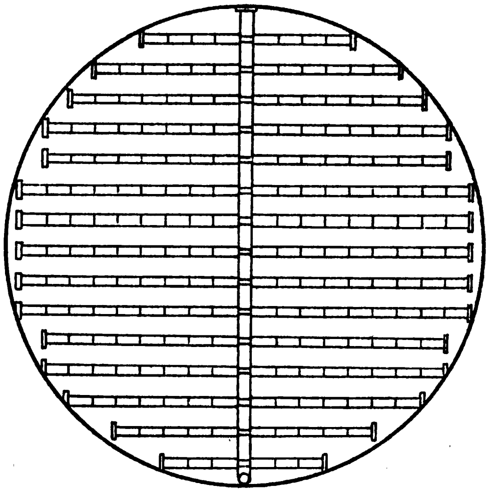


FIG. 97.—Showing ground plan of lawn bed arranged for sub-irrigation.

This plan of sub-irrigation, however, is open to several objections, among which are the following: The enormous quantity of water required, much of which is no doubt lost by seepage; the tendency of the water to rise rapidly to the surface of the bed at a few points and overflow before the main portion has become saturated. If the bed is located on sloping ground the water will frequently "break out" at the lowest point, often several inches from the circumference of the bed. In the case of beds as large as the one described a large stream or head of water is required so as to maintain pressure in the tiles sufficient to force the water to the surface. In the experiment described a three-fourths inch stream for 24 hours had no apparent effect in wetting the soil in the bed.

Experiments in 1901.—An experiment conducted during the past season furnished opportunity for a comparison of different methods of sub-irrigation with surface watering.

Three beds, each five and one-half by eight feet, located on sloping ground, were prepared as follows: *Bed No. 1,* designed for surface watering, was simply spaded to a depth of one foot

and leveled for planting. *Bed No. 2* was excavated to a depth of 17 inches, the bottom covered with two inches of cement and the sides bricked to a height of 12 inches and covered with a thin layer of cement. A layer of gravel, two inches in depth, was then spread over the bottom and over this a thin covering of freshly cut grass, sufficient to prevent the soil from filling the spaces between the gravel stones. A vertical tile was then set at one end, with the lower end slightly raised above the cement bottom, to serve as an inlet for water. It will be observed that the brick lining was not extended to the surface. The expense was thereby lessened and an opening provided for the escape of surplus water by capillarity.

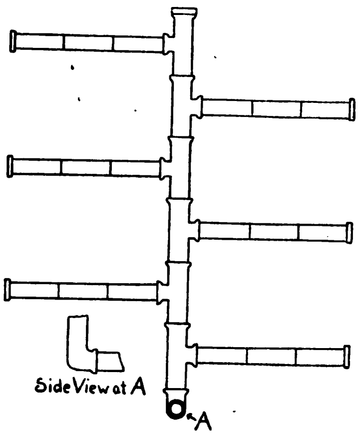


FIG. 98.—Showing ground plan of bed No. 3, arranged for sub-irrigation.

Bed No. 3 was excavated to a depth of 15 inches and the clay bottom and sides "puddled" thoroughly by mixing water with crumbled clay to form a paste. Eighteen sections of 3-inch tile were then laid on the bottom of the bed, as shown in Fig. 98. The sections of the main line were glazed sewer pipe, known to the trade as "tees," the laterals were common drain tile. The sections of the branch lines were laid close together and the outer ends closed. The end opposite A was also closed, and at A, a vertical inlet pipe was cemented to the first section of the main line. The beds were then refilled with earth and prepared for planting. Species of plants were selected that require an abun-

dant supply of water in order to make a satisfactory growth. On June 6th the following were set in each bed:

Three Castor Bean, 1 Caladium, 2 Cosmos, 6 Pennisetum, 16 Coleus and 6 Canna plants. The beds were watered immediately after planting, by means of a three-quarter inch hose connected with a water system affording considerable pressure.

In watering, bed No. 2 (cement) was supplied with water until the surface appeared moist; the amount required was noted and an equal amount applied to bed No. 1 and bed No. 3. As only a portion of the water would be absorbed by the soil in No. 1, even when applied slowly and with great care, a barrel was sunk in the ground alongside the bed to receive the overflow which could then be measured.

At the first watering 148 gallons were required to wet No. 2 (cement), which amount was not sufficient to wet the soil to the surface in No. 3 (tile), while but 36 gallons could be supplied to the surface bed. At subsequent waterings from 48 to 50 gallons were required for No. 2 and No. 3 and about one-half of this amount was retained in No. 1.

The beds were watered as needed until Sept. 16th, which, owing to the extremely dry season, was about once a week. The results were decidedly in favor of sub-irrigation. The plants in bed No. 2 made a stronger growth and were at all times more vigorous and blossomed more freely than those in either of the other beds. No. 3 was a close second but at all times lagged behind No. 2. The plants in bed No. 1 (surface) grew to about one-half the height of those in No. 2 and were less vigorous. Fig. 99 and Fig. 100 show the comparative size of the plants in the different beds. The surface-watered bed appears at the right in Fig. 99 and at the left in Fig. 100. The following table shows the average height of the plants:

FIG. 99.—Showing one surface-watered (right) and two sub-irrigated beds. The middle bed (No. 2) cement lined, and the right (No. 3) tile on clay bottom.

FIG. 100.—Showing surface-watered and sub-irrigated beds. The surface-watered bed appears at the right.

Table showing the average height of the different species of plants in sub-irrigated and surface-watered beds.

	Castor bean.	Cosmos.	Coleus.	Pennisetum.
	Feet.	Feet.	Feet.	Feet.
No. 1, surface	4.8	4.7	1.7	3.7
No. 2, cement	8.0	5.0	3.2	4.7
No. 3, tile	7.0	4.7	2.5	4.5

The cost of construction of beds No. 2 and No. 3 over that of No. 1 is as follows:

Bed No. 2.

106 brick at 80 cts. per C	$ .85
125 lbs. Portland cement	1.25
2 sections 3-inch tile for inlet	.02
10 hrs. labor excavating, etc	1.50
6 hrs. mason	1.50
Total	$5.12

Bed No. 3.

6 sections sewer pipe at 35 cts	$2.10
12 sections drain tile at 1 ct.	.12
8 hrs. labor at 15 cts	1.20
Total	$3.42

While the cost of the tile is less than the cement bottom the results obtained were not as satisfactory, and it is open to the objections cited in the original experiments.

SUMMARY.

Flower beds require more water than similar spaces devoted to farm or garden crops; in fact an abundant supply of water at all times is essential to success. This water can be best and most economically supplied by sub-irrigation.

A permanent, water-tight basin has proved more satisfactory than tile laid on an earth bottom.

The added expense of construction may be counted as a permanent improvement to the premises. The pleasure derived from the luxuriant growth and wealth of bloom may also be reckoned as compensation.

THE INFLUENCE OF FORMALIN ON THE GERMINATION OF OATS.

F. CRANEFIELD.

The most approved method of treating seed oats for the prevention of oat smut consists in wetting the seed thoroughly with a solution of formalin in water.

One pound (pint) of formalin is added to 50 gallons of water (being equal to $2\frac{1}{2}$ parts to 1,000), and the seed thoroughly sprinkled with the solution, or better, immersed in it for 20 minutes and then spread out to dry before sowing.

Either method is effectual in destroying the spores of smut on the seed and a crop free from smut may be expected from such seed if it is not again infected before sowing. The methods employed have been discussed in previous publications of this Station and will not be taken up here, but the influence of the treatment on the germination of the seed and the vigor of the plants suggests many questions, some of which follow:

(1) Does the formalin solution at the rate of 1 pint to 50 gallons injure the germinative power of seed immersed in it for 20 minutes?

(2) May a stronger solution be used without injury to the seed?

(3) May seed oats be immersed in the standard solution (1 pint to 50 gallons) for a longer time than 20 minutes without injury to the seed?

(4) How does the treatment affect the vigor of the plants?

In order to obtain data on these subjects the following ger mination tests were conducted. Samples of each of 20 varieties of oats were taken from crops grown on the Station grounds the

past season, numbered from 1 to 20, and one sample of each, tied loosely in a cheese-cloth sack, was immersed for 20 minutes in a solution of formalin of standard strength. (*2 1-2 parts to 1,000.*)

As a check, or control, similar samples were soaked for 20 minutes in hydrant water. After drying, 100 seeds of each of the 40 samples were placed in a Geneva seed tester (an apparatus so arranged that a large number of samples may be tested at once and under similar conditions), and a daily record kept of the number of germinations.

Three tests were made in this way, the results being shown in the following table:

Table showing the percentage of germination of oats treated and untreated, the difference in germination and the average percentage of injury.

No	FIRST TEST.			SECOND TEST.			THIRD TEST.			Average percentage of injury.
	Un-treated	Treat-ed.	Differ-ence.	Un-treated	Treat-ed.	Differ-ence.	Un-treated	Treat-ed.	Differ-ence.	
1	83	79	4	83	82	6	84	89	5*	1⅔
2	95	88	7	99	91	8	96	94	2	5⅔
3	97	83	14	90	86	4	90	93	3*	5
4	95	62	33	97	70	27	96	94	2	20⅔
5	90	88	2	92	79	13	99	97	2	5⅔
6	85	79	6	88	88	0	92	89	3	3
7	91	79	12	96	87	9	100	94	6	9
8	94	74	20	90	86	4	93	93	0	8
9	98	86	12	97	96	1	96	96	0	4⅓
10	99	77	22	95	84	11	97	94	3	12
11	94	85	9	97	81	16	100	95	5	10
12	94	69	25	86	92	6*	91	95	4*	5
13	88	68	20	89	86	3	85	83	2	8⅓
14	90	79	11	93	80	13	88	83	5	9⅔
15	95	78	17	92	86	6	100	90	10	11
16	88	89	1*	91	86	5	99	97	2	2
17	99	91	8	94	92	2	....	....	....	5
18	97	91	6	92	77	15	97	92	5	8⅔
19	93	85	8	95	85	10	94	85	9	9
20	80	61	19	65	67	2*	80	70	10	9

* Per cent. gain.

By observing the figures in the right hand colum it will be seen that the average percentage of injury as the result of treatment varies from 1 2-3 per cent. in No. 1 to 20 2-3 per cent. in No. 4. In a few cases, those marked by an asterisk, the treated seed germinated better than the untreated, in all others the treatment injured the seed.

In addition to these tests two soil tests were made. One hundred seeds of each variety were planted in the greenhouse in shallow boxes filled with soil. The following table shows the results:

Table showing percentage of germination; difference in germination and average percentage of injury of oats treated and untreated.

No.	1st Soil Test.			2d Soil Test.			Average per cent. injury.
	Untreated.	Treated.	Difference.	Untreated.	Treated.	Difference.	
1	89	34	55	79	49	30	42½
2	87	84	3	83	70	13	8
3	92	73	19	90	72	18	18½
4	93	68	25	91	70	21	23
5	89*	91*	2*	91	70	21	9½
6	92	79	13	87	71	16	14½
7	92	79	13	94	69	25	19
8	82	78	4	81	61	20	12
9	94	79	15	92	65	27	21
10	86	85	1	88	64	24	12½
11	98	79	19	84	63	21	20
12	87	74	13	77	54	23	18
13	76	63	13	64	51	13	13
14	91*	92*	1*	57	48	9	4
15	93	82	11	91	65	26	18½
16	89	85	4	85	48	37	20½
18	87	77	10	63	46	17	13½
19	69	50	19	79	57	12	15½

* Per cent gain.

As may be seen from the above the injury varied from 4 per cent. in No. 14 to 42½ per cent. in No. 1. In two cases in the first test, Nos. 5 and 14, the treated seed germinated better than the untreated.

In order to determine the effect of solutions of formalin of varying strength on germination, nine solutions were prepared, viz.: 1 pint to 50 gallons, 1 pint to 45 gallons, etc., the strongest solution used being 1 pint to 5 gallons.

A sample of No. 18 oats was immersed in each of the solutions for 20 minutes, as well as one in hydrant water. After drying, 100 seeds of each lot were placed in the Geneva tester. The results of the tests are given in the following table:

Table showing per cent. of germination of oats treated to solutions of formalin of varying strength.

Strength of solution.	First test.	Second test.	Average.
1 pint to 5 gallons	15	9	12
1 pint to 10 gallons	23	29	31
1 pint to 20 gallons	71	75	73
1 pint to 25 gallons	72	76	74
1 pint to 30 gallons	89	88	88.5
1 pint to 35 gallons	83	93	88
1 pint to 40 gallons	82	93	87.5
1 pint te 45 gallons	86	93	89.5
i pint to 50 gallons	87	95	91
Hydrant water	92	97	94.5

The results of these tests show the marked influence of formalin on the germination of oats when used in solutions stronger than 1 pint to 50 gallons, the injury increasing in direct proportion to the increase in the strength of the solution used.

No serious injury appeared to result from soaking the seed for a longer period than 20 minutes, as may be seen from the following table showing the average of four tests:

Table showing the average percentage of germination of 4 varieties of oats treated to formalin for periods varying from 20 minutes to 24 hours.

Time of treatment.	No. 5.	No. 10.	No. 12.	No. 14
Treated 20 minutes	85.0	89.5	78.0	74.0
Treated 1 hour	92.0	87.0	81.5	68.5
Treated 2 hours	86.3	89.0	81.5	73.0
Treated 3 hours	88.0	93.0	88.0	84.0
Treated 24 hours	82.0	78.0	52.0	78.0
Untreated, but soaked in water 3 hours	93.0	90.6	88	85.0
Untreated, not soaked	95.0	92.0	90	85.0

As may be seen from this the treatment of the seed for 20 minutes caused a perceptible injury, but the treatment for a longer period did not appear to effect a corresponding injury.

The effect of the treatment on the growth of the plants was very marked in every case, the growth of the plants from the treated seed being decidedly checked at first. Later, however, the growth was more nearly equal, but the plants from the

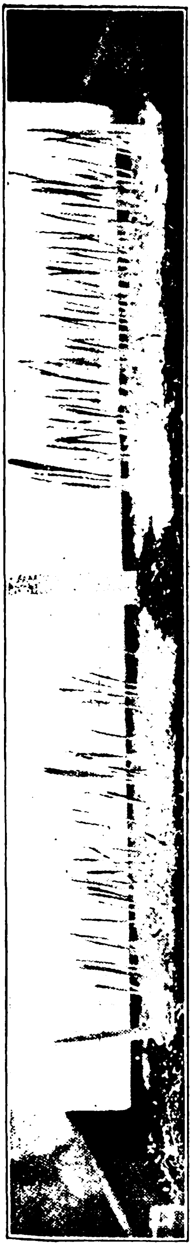


FIG. 101.—Showing 7 days' growth of oat plants from treated seed (left), and untreated (right).

FIG. 102.—Showing 15 days' growth of oat plants from treated seed (left), and untreated (right).

treated seed did not at any time equal in height those from the untreated seed. It is well to note, however, that the plants were grown in but three inches of soil. Had they been in the open ground it is possible that at maturity the growth of the plants from the treated seed might have equaled that of the un-

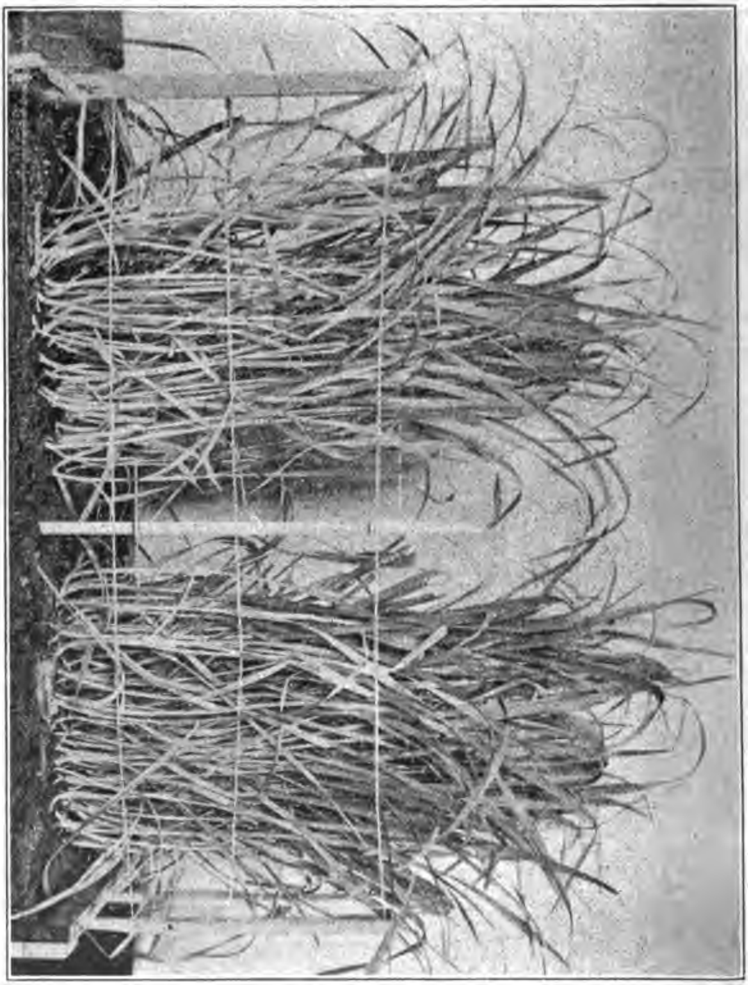


FIG. 103.—Showing 30 days' growth of oat plants from treated seed (left) and untreated (right).

treated seed. Fig. 101 shows 7 days' growth of two groups of plants of No. 6, the group on the left being from treated seed and the one on the right from untreated seed. Fig. 102 shows 15 days' growth of the same groups, and Fig. 103, 30 days' growth. Fig. 104 shows three lots of plants grown from seed of

No. 18, the two outer pairs of rows from untreated seed and the pair in the middle from treated seed. Fig. 105 shows two lots of plants of No. 18 grown wholly in water. The ones on the right are from untreated seed and those on the left from treated seed. Fig. 106 shows the same plants at a later date.

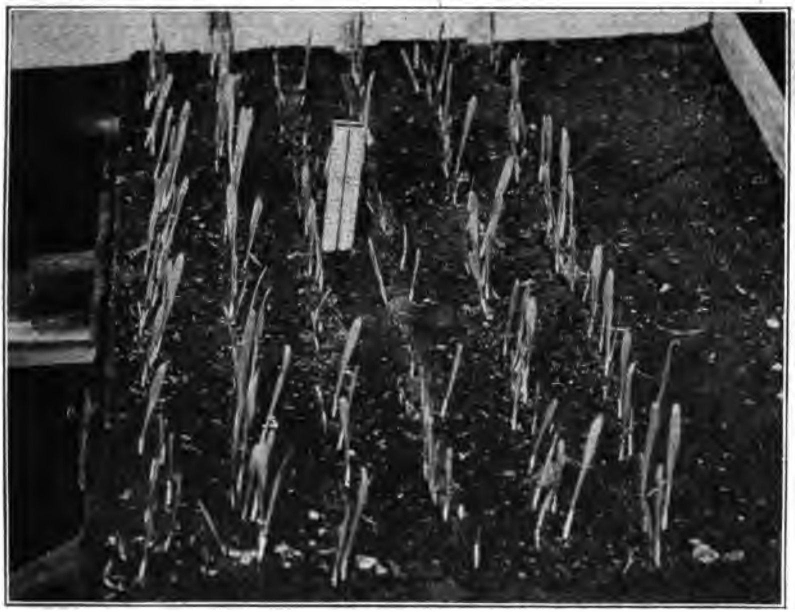


FIG. 104.—Showing three lots of oat plants; the middle pair of rows from treated seed and the two outer pairs from untreated seed.

Professor Bolley of the North Dakota Station gives results widely different from the above. The following is quoted from p. 161 of Bulletin 27, North Dakota Experiment Station:

. . . . . "Many germination tests of the effects of this substance (formaldehyde) upon selected wheat and oats have been perfected, and it is found that such grain is benefited and improved in germinating power by this chemical. The untreated samples which were tested as checks were soaked in distilled water periods of time equivalent to that of the formalin treatment. This allows one to decide that the benefit of the formalin treatment upon the seed is not due alone to the moisture taken up. Either sort of grain germinates perfectly and

unusually rapid after soaking one to three hours in a solution of the strength of 4 parts to 1,000."

A comparison of these statements with the above experiments leads to the conclusion that oats grown in different places may be affected differently by the formalin treatment.

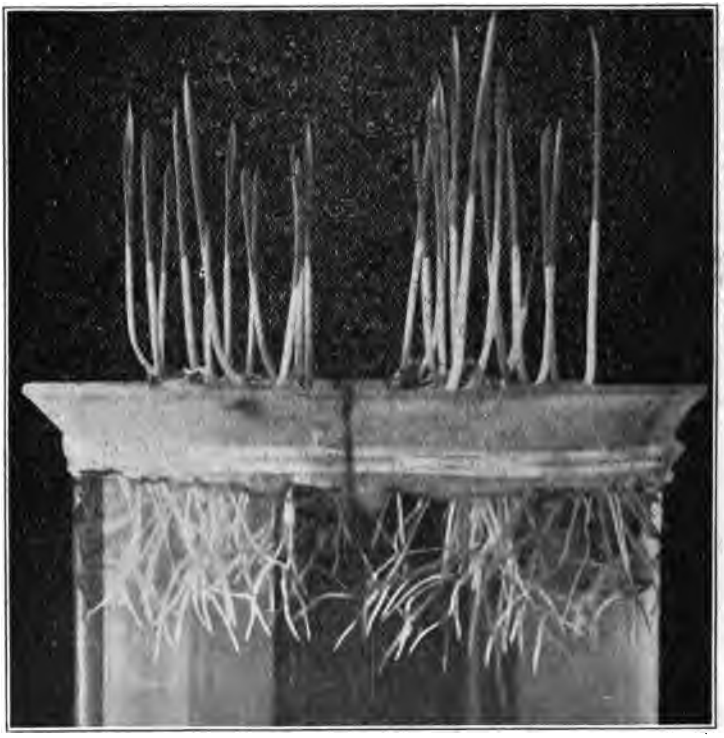


FIG. 105.—Showing two groups of oats plants grown wholly in water, the one on the right from untreated seed and on the left from treated seed.

Summary.—The experiments described above, covering the germination of over 25,000 seeds, lead to the conclusion: that a formalin solution as weak as 2½ parts to 1,000 may injure oats for seed; that in the case of the varieties tested the injury increased as the strength of the solution was increased; that an increase in the length of time does not proportionately increase the injury when the standard formula is used (2½ parts to 1,000); that the growth of the plants appears to be checked at first as a result of treating the seed, but at the end of 30 days